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NOTES ON THE BREEDING CYCLE OF CAPE VULTURES (*Gyps coprotheres*)

ALISTAIR S. ROBERTSON

ABSTRACT - Observations were made of the pre-laying, incubation and nestling periods of the Cape Vulture (*Gyps coprotheres*) at a colony in the southwestern Cape Province, South Africa. Some members of the colony were colour-ringed as nestlings; this allowed the sex of breeding partners to be determined by subsequent observation of copulation. Information on occupancy of nest sites, nest-building, a sex-related behavioural difference, dates of egg-laying, incubation and nestling periods, parasite infestation (*Prosimulium* spp.), and associated blood parasites (*Leucocytozoon*) of nestlings is presented.

The Cape Vulture (*Gyps coprotheres*) is the heaviest endemic accipitrid in southern Africa and is the only vulture in the region to breed in colonies on cliff faces (Mundy 1982). Approximately 3500 Cape Vulture nestlings have been colour-ringed (banded) in southern Africa since 1974; studies of marked birds, however, are mostly confined to aspects of dispersal and survival (Houston 1974; Piper et al. 1981; Mundy 1982).

Here I present results of observations made during a case study of a particular colony, to supplement Mundy (1982) and provide information on the behaviour of colour- and metal-ringed breeding adults. Sexes of *Gyps* are morphologically indistinguishable in the field (Houston 1976; Mundy 1982), therefore marked birds provided an opportunity to investigate behavioural differences between sexes, as well as nest-site fidelity (Robertson 1984). The pre-laying, incubation and nestling periods (Newton 1979) are considered separately; observations on the post-fledging dependence period and copulatory behaviour are described elsewhere (Robertson 1983, 1985).

STUDY AREA AND METHODS

Observations were made at a colony in the Potberg (34° 22' S; 20° 33' E), approximately 10 km from the Indian Ocean coast and approximately 50 km northeast of the southern tip of Africa. About 50 vultures inhabit a ravine of the mountain, and use cliffs facing southeast and southwest for nest and roost sites. In addition, a smaller colony of about 20 at Aasvogelvllei, 120 km from Potberg, was monitored for numbers and breeding success.

The region has a temperate Mediterranean climate and receives most of its rainfall (≈ 530 mm/y) from about May to September (i.e., winter).

All active nest sites and roosting ledges were visible from the southeast side of the ravine, 300-400 m away. Observations were made with binoculars and a 15-60x telescope. Observations began in May 1981, continued for 12 d each month regardless of weather conditions, and ended in May 1982. One "day" represents the time period 0730 H - 1630 H. The concluding stages of the 1980 breeding season, all stages of the 1981 season and the initiation of the 1982 season were covered. Presence of birds at sites and roosting ledges was noted every 30 min during each observation day; the proportion of each class (i.e., one, both or neither occupant present at each count during an observation day) was determined and converted to an arcsine transformation (Scheffler 1969). Although most of the breeding pairs were not individually recognizable, some ringed breeders were present. At a nest where both birds were colour-ringed, strangers alone at the nest for longer than 5 min were seen only 3 times. Unless shown to the contrary, vultures observed at a site were regarded as the occupants. Individual vultures were age-estimated using the characters given by Mundy (1982). At nests where at least one partner was ringed, sex was determined by observation of copulation attempts.

Laying dates for 1981 and 1982 were determined by checking the colony regularly, although precise dates for 3 nests were not obtained in 1982. Dates for 1977, 1979 and 1980 as well as the dates of laying in both 1981 and 1982 at Aasvogelvllei were estimated using an average incubation period of 57 d and a known-age/wing length curve (Mundy 1982). Wing lengths of nestlings measured before 1981 were obtained from unpublished records; thus, only laying dates of sites that produced large nestlings were obtained for years other than 1981 and 1982.

Nestlings at both colonies were colour-ringed, weighed and measured as part of the colour ringing scheme on Cape Vultures (Ledger 1974). Nests were visited on 5 other occasions in order to collect added eggs or shell fragments (measurements in Robertson 1984) and to replace an egg that an adult had knocked from the nest cup. In 1981, nestling blood samples were obtained from both colonies. Smears were prepared following Greiner & Mundy (1979) and scanned for blood parasites by M.B. Markus.

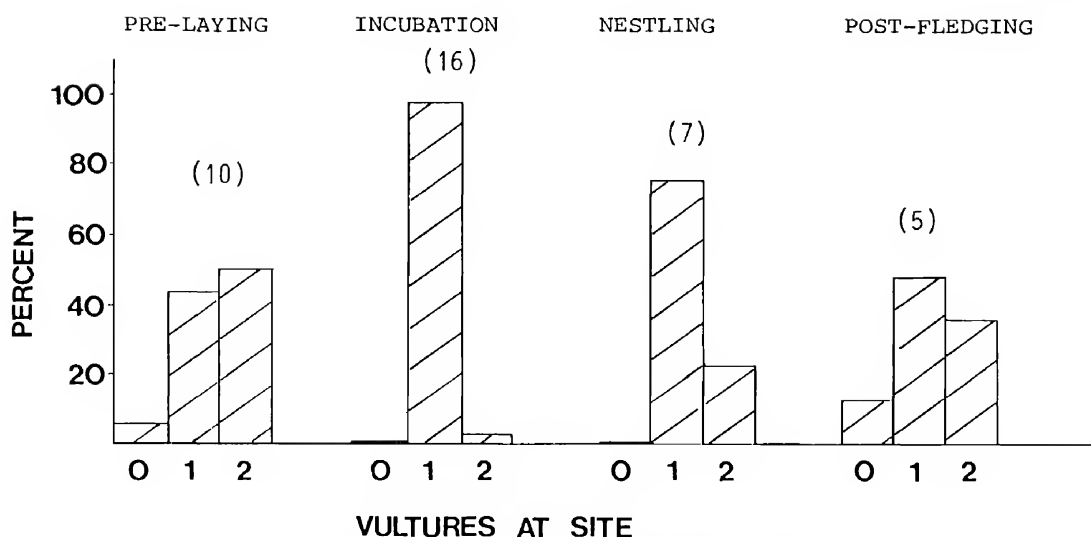


Figure 1: The average level of occupancy of nests during different periods of the breeding cycle. The number of nests used in the calculations for each period is indicated.

RESULTS

Pre-laying period. — Because of the length of the breeding cycle, certain pairs displayed an overlap of post-fledging and pre-laying periods (Robertson 1985). Other pairs that failed in breeding retained their nest site (by aggressively chasing off visitors) from the date of failure.

Figure 1 depicts the average occupancy of 10 nests for the 1981 pre-laying period. On average, nest sites were left vacant for 5% of the observation time.

(a) Activation of nest sites. — Of 17 breeding sites active in 1981, 14 were active again in 1982. Of 4 additional nests active in 1982, one was active in 1980. Thus only 3 sites were initiated during the observation period.

At one site on 29 October 1981, 2 birds were seen to stand very close together, facing inwards and picking at sticks on the surface. Seven min later, the ringed female occupant landed at the site and repulsed both, which then repeated this behaviour at another (vacant) site. The impression was of a pair "prospecting" for a possible future breeding site, about 7 months before the next season's average laying date.

At another site, an immature male (est. 3rd y) and female (est. 4th y) were observed to copulate 36 times between 30 June and 30 December 1981. On most occasions after the copulation attempt, both

birds bent over and picked at the nest contents. The nest was examined on 8 October and consisted of a few sticks and green sprays — an "intermediate" nest structure. The first intruder repulsion at this site was observed on 20 December. This site produced a fledgling in 1982/3, thus it was effectively activated in mid-1981, if the parents are assumed to be the same individuals.

A probable mate replacement (certainly the initiation of breeding) occurred at one site in 1983, where a colour-ringed, 6 y old female was observed from late December 1982. This site was active in 1980 and 1981 (both partners adult and unringed). The 6 y old's sex was determined by observation of a copulation attempt with an unknown adult at a perch on 18 May 1982.

(b) Nest-building. — No sign of nest-building at any site was observed before the end of March 1982, and at only 2 sites, successful in the previous cycle, were there any remains of the nest structure. By the end of December 1981, nest material on the sites of all failed breeding attempts had disappeared. Collection of nest material in earnest was first observed on 25 April 1982, about 10 wk before the average laying date. Branches comprising the nest structure were collected in most cases from 2 separate areas on the ravine slopes and carried back to the nest in the bill.

At 6 nests where male and female were distinguished, frequency of collecting forays by either sex

was determined. Collecting forays were mainly determined for 3 nests only — those situated on the cliff directly opposite the observation point where the collector's sex was determined with greater certainty. Of 98 collections, males collected 75 times (76%), far more than did females, although at one nest the difference was not so marked. The female generally packed the material into the structure, although both sexes were often seen bending over and rearranging material.

Incubation period. — In 1981, 356 nest-d of observation of 16 nests with eggs were made, and I made a further 99 nest-d of observation during an 8-d consecutive period in 1982.

No double clutches (Mundy & Ledger 1975) or replacement clutches were recorded, although the egg at nest #55 was laid 40 d later than the estimated 5 June mean for that year and may thus have been a replacement clutch.

For 16 incubation periods in 1981, which includes one egg lost after 41 d, one adult was at the site at 97.7% of the counts (range 91.2% - 100%).

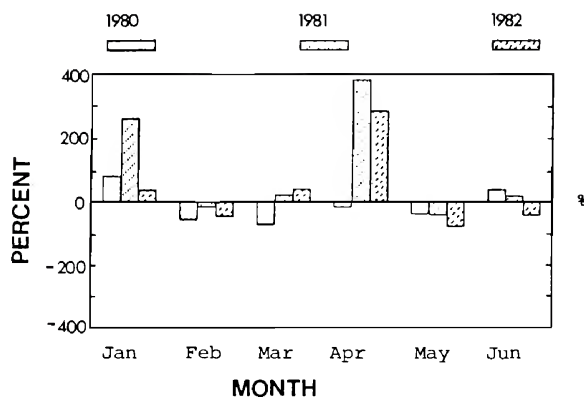


Figure 3: Rainfall in the six months preceding egg-laying, expressed as a percentage deviation above and below the monthly mean.

These sites were unoccupied only 0.09% of this observation period, where an average of 359 thirty-min counts were made per nest. (Fig. 1). On average, 2 birds were at the site 2.0% of the time (range 0% - 8.8%). Birds generally incubated the

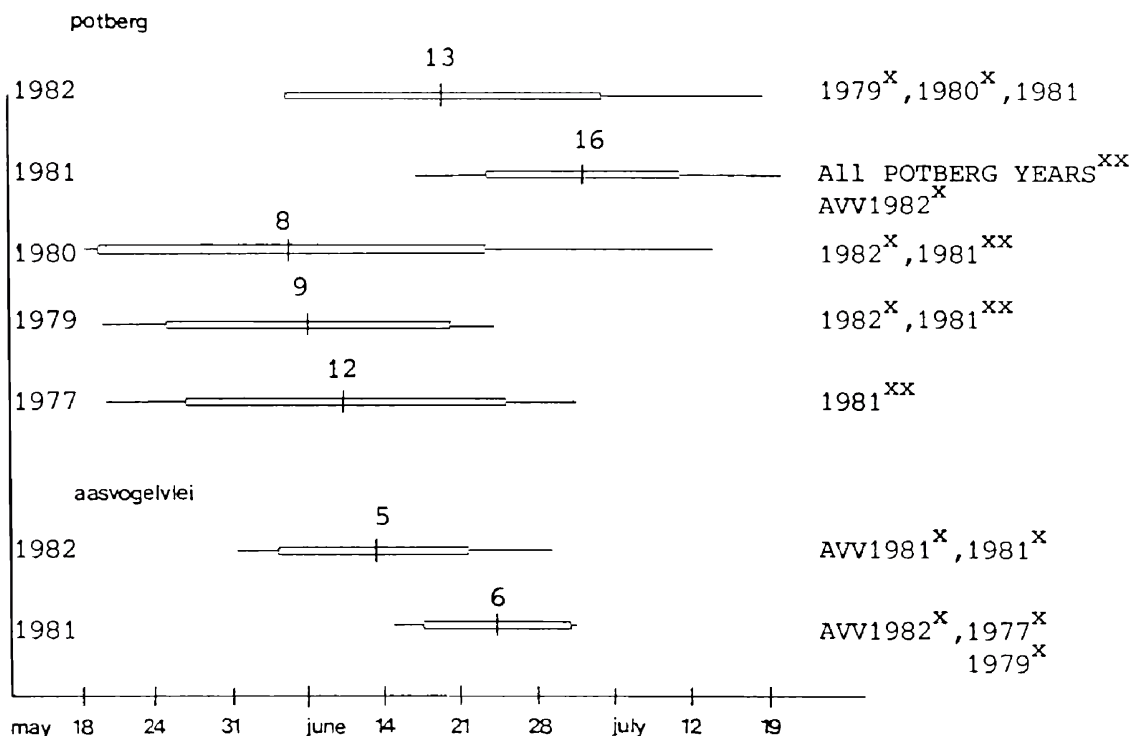


Figure 2: Dates of egg-laying at Potberg and Aasvogelvlei. The mean ($\pm$ s.d.) and range are shown, as well as significant differences in dates of laying between the various years (0.01 level: year^{xx}; 0.05 level: year^x).

egg very tightly and on only one occasion did an adult leave an egg unoccupied (for 182 min) for no apparent reason.

(a) Date of laying. — Only in 1977 did the correlation of higher rainfall and later mean date not occur, although the differences are very slight (compare Figs. 2 and 3). The 1981 mean laying date was significantly later than any other year at Potberg, and similar only to the mean for the same year at Aasvogelvlei (t-Test, 20d.f., $P = 0.09$). The overall average laying date for the 5 y is 17 June (s.d. = 17.5 d, n eggs = 58), and this is clearly later than the early-May average for the Skeerpoort, Magaliesberg colony (Mundy 1982) and the similar average for the Collywobbles, Transkei colony (Vernon et al. 1982).

All 1981 eggs were laid considerably later than in 1980, except the likely replacement clutch mentioned. Considering the 3 long, post-fledging dependence periods observed in 1981/2 (Robertson 1985), an egg was laid at the same site before the mean 1981 laying date on one occasion and after it on another; the third site was not active in the subsequent season. After the post-fledging dependence periods observed in 1981/2, eggs were laid at the same sites before the mean 1982 date on 4 of 5 occasions and significantly later by the same adults (colour-ringed) in one instance. At the site with the longest 1981 post-fledging dependence period, the following year's egg was laid before the colony's mean egg-laying date for that year.

The most accurate times of laying were obtained for 3 eggs in 1981, where eggs were laid between 1630 H and 0730 H the next day. At one site (nest #63), the same colour-ringed female laid an egg in 1982 between 1730 H and 1500 H, on exactly the same date as the previous year.

(b) Changeovers and attentive periods. — Changeovers (nest relief) occurred within about 3 min of the mate's arrival, although certain partners gave the impression of being "reluctant" to leave. In such cases, changeovers occurred after the incubator had been gently nudged off the nest; this was more frequent during the nestling period. During what was most likely the first changeover at one nest, the incoming adult allowed the egg to roll out of the cup by standing on the rim. After a few feeble attempts at replacing the egg with its bill, it continued to "incubate" the empty nest. During the next 90 min, the bird tried 3 times to replace the egg which lay some 8 cm from the rim. I replaced the

egg at 1540 H, after it had been exposed for 430 min (clear weather, 9-13 knot breeze). This egg subsequently produced a juvenile that fledged. A total of 186 changeovers of birds incubating eggs were noted in 1981, averaging 11.6/site, or 0.5/nest-d of observation. A number of changeovers at outlying sites were probably missed. If the ledge directly opposite the observation point is considered alone, 61 changeovers were documented for 4 incubation periods during 88 nest-d (0.7 changeovers/nest/day). Rarely up to 3 changeovers might occur on the same day. Changeovers occurred in the mornings, before a day's foraging, or in the afternoon after foraging. The earliest time where the incoming partner had fed that morning (bulging crop observed) was 1130 H; if changeovers are then divided into pre-1130 H (61, or 33%) and post-1130 H groups (125, or 67%), then incoming adults had obtained food on 64% of the latter (8.6% cases unknown). The overall average changeover time was 12 hr 54 min, 50 min earlier than that documented for the Skeerpoort, Magaliesberg colony (Mundy 1982:161).

Incubating birds occasionally stood up to stretch, flap their wings, repulse intruders or move the egg (along its long axis, Mundy 1982), and the longest period in such cases that the egg was exposed was 4 min ($n = 18$, $\bar{x} = 1.2$ min). Attentive periods have been divided into those where 2 changeovers occurred within one observation day ("within-day"), and longer stints. In 1981, the mean "within-day" attentive period was 3 hr 15 min ($n = 44$), which was not significantly different from the 3 hr 31 min period in 1982 (t-Test, 60d.f., $P = 0.30$). The mean of 1981 "long" attentive periods was 26 hr 21 min ($n = 72$), significantly longer than the 1982 mean of 22 hr 35 min (t-Test, 98d.f., $P = 0.01$). If 11 abnormally long attentive periods (mean 44 hr 3 min, range 40 hr 45 min - 48 hr 8 min) are excluded, the 1981 mean is not significantly longer than that obtained for 1982 (t-Test, 86d.f., $P = 0.37$). In 5 of these extra-long cases, the individual concerned was ringed, confirming that no changeover had been missed.

Sexes could be distinguished at 5 nests by the presence of either a metal-ringed (2 nests) or colour-ringed partner. Only when a ring was clearly resighted at both changeovers, were the corresponding attentive periods used in analysis of any sex-related differences. The mean for males (1981 and 1982 values combined) was not significantly

longer than that for females (t-Test, 30d.f., $P = 0.32$). The frequency of attentive periods by either sex was not significantly different (χ^2 "=" expected values test, $P = 0.72$).

Five eggs failed to hatch in 1981 and 1982. In 2 cases no change in incubation behaviour after the expected hatching date was noted. For example, adults at nest #29 continued to incubate normally for 18 d after the expected hatching date, until I collected the egg. At one nest, however, the incubating adult tended to stand over the egg, rather than sit on it from about 14 d after the expected hatching date. Twenty-four days after the expected hatching date, the incumbent adult deserted this egg for 152 min, returned to stand near it for 355 min, to leave it unattended that night (I collected the egg the next day).

At 6 sites in 1981 where both laying and hatching dates were accurately obtained, the average incubation period was 57 d (95% C.L.'s 55.6 - 58.4).

Nestling period. — At 10 sites with nestlings, 377 d of observation were made in 1981, and 15 nest-d at 4 nests in 1982. In 1981, 7 nestlings lived longer than 11 d and 6 fledged, and of 10 nestlings colour-ringed in 1982, 7 fledged (Robertson 1984).

Only 11% of copulation attempts observed at successful sites through the 1981 cycle occurred during the nestling period (Robertson 1983). The mean hatching date for the years 1977 and 1979-1982 was 14 August (using mean laying date of 17 June and a 57-d incubation period).

(a) Parental care of nestling. — In 1981, nestlings at 7 nests were left unattended for 1.2% of the counts (range 0.1% - 4.5%). One nestling was unattended for significantly more time than 3 others (Sheffe's tests, $P < 0.05$). Six nestlings were unattended at least once during the period (*i.e.*, one never), and the average age at the first such instance was 71.7 d (range 41-93 d). Nestlings were accompanied by 1 adult on 76.4% of the counts (Fig. 1). Both adults were at the nest on 22.4% of the counts; in all cases attendance by both parents was greater than during incubation.

In 1981 sexes were distinguishable at only one active nest and both partners attended the nestling for similar lengths of time (t-Test, 21d.f., $P = 0.43$). Both male and female attendance periods were significantly shorter than those obtained during the incubation period (t-Tests, $P < 0.01$).

The mean "long" attendance period of 21 hr 56 min ($n = 71$) was not significantly shorter than the mean for incubation, if the 11 "extra-long" stints are excluded (t-Test, 129d.f., $P = 0.09$). If these values are included, the difference becomes significant. The mean "within day" attentive period of 3 hr 39 min ($n = 53$) was not significantly longer than the value for the incubation period (t-Test, 95d.f., $P = 0.17$). The average changeover time was 1229 H, significantly earlier than that documented for the incubation period (t-Test, 375d.f., $P = 0.49$). Of 193 changeovers, 65.8% occurred after 1130 H and on 86% of these, the incoming adult had obtained food.

For its first few weeks, the nestling was brooded closely by the adult, making the precise time of hatching difficult to discern. There was subsequently a gradation in attendance behaviour of parents, particularly after the nestling was dorsally feathered. A 4-month-old nestling wandered 2 m to an adjacent site containing a 5-month-old nestling on 3 times; both pecked gently at each other's necks before being aggressively jabbed at by an attendant adult. Similar behaviour was never observed for adults of adjacent sites. Parents continued to bring sprays of fresh green leaves to the nest during this period.

Most feeding was bill-to-bill, with the nestling actively calling and tapping the parent's bill. On at least 7 occasions, parents that had not fed were observed to go through the motions of regurgitating seemingly without any food appearing. Nestling development has been described by Mundy (1982), and correlations of wing with body mass and age are presented in Robertson and Boshoff (in press).

(b) Parasite infestation. — All nestlings visited on 8 October 1981 were infested with black flies *Prosimulium* spp. (identified by J.S. Paterson). The average age of these nestlings was 43 d (range 22-55 d). The heaviest infestation was on a 47-d-old nestling, where one-half of the head was fully covered (Fig. 4). The main area affected was the crown, but one nestling showed 2 areas of infestation under the wing. The infestation on one nestling, that was unattended while adjacent nestlings were ringed, increased on its head and back, *i.e.*, the presence of the adult (that had flown because of my presence) affected the degree of infestation. This was confirmed later by observing attendant adults removing flies from nestlings with their bills. When



Figure 4: Simuliid infestation (dark area on the otherwise white head) of a 47-day old Cape Vulture nestling.

all nestlings were visited 34 d later, only one fly was observed on the head of an 83-d-old nestling. One 55-d-old nestling had a very low *Leucocytozoon* infection (2 gametocytes in a blood smear); no infection was noted for the same individual in 2 smears taken 34 d earlier. *Plasmodium* spp., microfilariae

and other protozoa were searched for but not found (M.B. Markus *in litt.*).

No simuliids were observed at Aasvogelvlei in either year, and examination of samples from 4 nestlings did not reveal the presence of any blood parasites.

In 1982, less than 10 black flies were present on the crowns of only 2 of 10 nestlings examined.

Figure 5 records the degrees of simuliid infestation for the years 1976-1982, relative to the rainfall for the 6 months before September (data from Boshoff and Currie 1981, unpubl. records).

(c) **Length of nestling period.** — Where no days of observation preceded the day the fledgling was first seen away from the nest, the fledging date was not accurately known (4 cases known to within 5 d). Where at least 2 observation days preceded the date of the first observed flight, that day was taken as the fledging date. In 1981, mean nestling periods were 148.0-150.3 d (range 139-171 d). Both these means were significantly longer than the 1982 mean of 137 d (range 124-147 d) (t-Test for mean of 148, 11d.f., $P = 0.04$). The individual with the 125-d nestling period was found dead an estimated 3 wk after fledging. The next shortest nestling period was 136 d, and this bird survived at least 5 mo.

The mean for all available nestling periods was 143 d, very similar to Mundy's (1982) estimate of 140 d. The mean 1981 fledging date was 21-23 January 1982, and this contrasts with 28 December for 1982 fledglings.

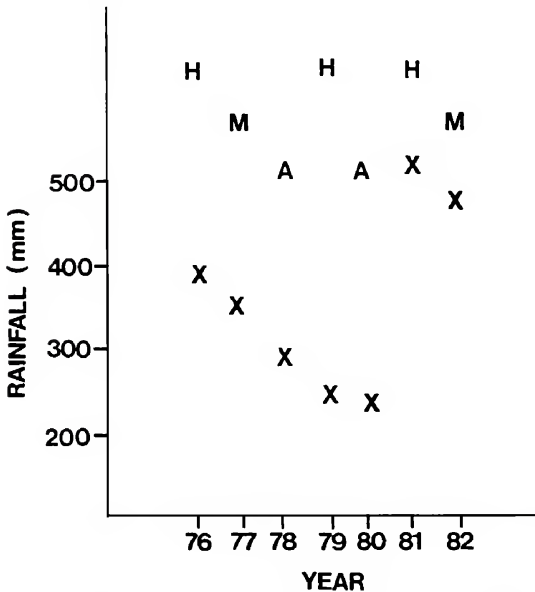


Figure 5: Simuliid presence related to the amount of rain in the six months preceding September. The degree of infestation is classed as heavy (H) (e.g., Fig. 4), medium (M) or absent (A), and the mean amount of rainfall for these months is shown (x).

DISCUSSION

The Pre-laying period. — Breeding sites are seemingly occupied about 6 mo or more before egg-laying. I can only conclude that pair formation preceded occupancy of a site: single vultures were not seen consistently at the few sites initiated during the study period. I discerned few courtship procedures except, perhaps, mutual preening and scapular action (Berruti 1981). Obviously, many signals perceived by either sex may not be perceived easily by human observers. In the Cape Vulture, pair formation occurs in association with the breeding colony, and specifically the nesting ledges, where 96% of all copulation attempts occurred (Robertson 1983). In contrast to the feeding area which, certainly in this colony's case, is totally man-influenced (Boshoff et al. 1984, Robertson

Table 1: Copulation attempts observed at the Potberg Cape Vulture colony during the study period.

SITE	(A) NO. BEFORE EGG LAID	(B) TOTAL OBSERVED MAY 81 - DEC 81	A/B	TOTAL OBSERVED JAN 82 - MAY 82	EGG LAID (E)
7	112	113	99.1	38	E
13	31	35	88.6	18	E
16	42	53	79.2	54	E
6	30	39	76.9	34	E
26	49	61	80.3	53	E
4	44	55	80.0	64	E
63	59	59	100.0	22	E
57	44	45	97.8	25	E
17	48	57	84.2	51	E
61	17	30	56.7	54	E
30	38	49	77.5	5	EE
18	39	49	79.6	48	E
57	31	31	100.0	46	E
29	39	57	68.4	4	-
45	21	21	100.0	0	-
3	54	54	100.0	1	-
2	-	32	-	30	E
50	-	8	-	25	E
25	-	24	-	71	E
64	-	0	-	19	E
8	-	117	-	21	-
57 ^a	-	34	-	-	-
Roost Points		56		21	
	Total	1079	Total	704	

and Boshoff in press), the breeding area is unaffected by man. Aspects of breeding behaviour that I observed that are not directly linked to feeding, e.g., nestling attendance and foraging times, might then be representative of the species throughout its range. Because nest material disappeared from some sites before the next season's cycle, the site rather than the nest structure (Newton 1979) would appear to be the more valuable resource.

Houston's (1976) observation of a sex-related difference in behaviour during this period is confirmed; males collected nest material more frequently than females. Such behaviour would reduce the female's energy expenditure; is it then related to production of the egg? Several female

raptors increase in mass before egg production (Newton 1979). However, in the Griffon Vulture that share parental duties, mass increase occurs in both sexes (Houston 1976). Thus energy is accumulated not merely to enable the female to produce eggs, but to supplement the energy budgets of both sexes during the breeding cycle (Newton 1979). Also, the Griffon Vulture clutch of one egg weighs 3-5% of the female's body weight (Mundy 1982) and, in contrast to smaller raptors, makes a relatively small demand on her reserves. Greater male participation in collecting forays may be related to some other factor, such as courtship (akin to gannet behaviour?, see Nelson 1976). In a review of dimorphism in predatory birds, Andersson and

Table 2: Copulation attempts observed per period of breeding cycle. The figures for nest no. 61 are in parentheses as the nestling disappeared before fledging, and the total for successful sites excludes this site.

NEST NUMBER	PRE-LAYING PERIOD A	A/E %	INCUBATION PERIOD B	B/E %	NESTLING PERIOD C	C/E %	POST-FLEDGING DEPENDENCE PERIOD (D)	D/E %	TOTAL NO. COPULATION OBSERVED (E)
6	31	75.6	8	19.5	0	0.0	2	4.9	41
17	47	62.6	8	10.6	20	26.6	0	0.0	75
16	42	38.8	2	1.8	15	13.8	49	45.4	108
18	37	-	1	-	-	-	-	-	38
29	38	-	5	-	-	-	-	-	43
4	44	73.3	0	0.0	13	21.7	3	5.0	60
26	47	-	6	-	-	-	-	-	53
61	16	(59.2)	0	0.0	(11)	(41.7)	-	-	27
30	38	-	0	-	-	-	-	-	38
13	27	-	2	-	-	-	-	-	29
57	30	-	0	-	-	-	-	-	30
55	46	-	0	-	-	-	-	-	46
45	21	-	0	-	-	-	-	-	21
3	45	-	0	-	-	-	-	-	45
63	49	69.0	0	0.0	2	2.9	20	28.2	71
7	112	96.5	0	0.0	3	2.6	1	0.8	116
MEAN		67.8		4.5		15.4		14.0	52.5

Norberg (1981) present hypotheses to account for the lack of (reversed) size dimorphism in colonial carrion feeders; the general lack of sexual differences recorded in this study accords with their predictions.

Incubation period. — The timing of egg-laying is apparently not related to success or failure of the previous season's breeding attempt, as indicated at the few sites where juveniles continued to solicit food from parents near the following season's laying date. This suggests that lengthy post-fledging dependence periods may not drain the female's reserves. Whether or not both parents contribute equally to supplying the juvenile with food is unknown, and deserves investigation.

Raptors in general lay earlier in good than in poor food conditions, and food therefore has both a proximate and an ultimate influence (Newton 1979). Long periods of rain or heavy cloud before laying inhibits vultures' foraging and presumably reduces the rate of body reserve accumulation. This could delay laying, and thereby account for the rain-correlated variations in mean laying date. The

markedly regular laying date of particular pairs (identifiable partners at nest #63 had laying dates exactly the same in both study years), however, may point to the operation of other proximate factors. Throughout the Cape Vulture's range there is a gradation in laying dates, from earliest in the Transvaal (early May) through to latest in the southwestern Cape (mid-June).

One should bear in mind that the food source of the Potberg colony is an "artifact" of stock-farming practices. Because the food source has changed markedly within the past century, it is unrealistic to relate overall timing of the colony's breeding cycle to its current food source. Houston (1976) concluded that the breeding season of *G. rueppellii* in East Africa was so timed that the fledging date coincided with a relatively abundant period of food. This link certainly does not hold at Potberg, where nestlings fledge during a time of relative decrease in, but still adequate, food abundance (Robertson and Boshoff in press).

The accurately determined incubation period length of 57 d compares favourably with the 56-d

estimate of Mundy (1982) and the 57.6 d period of Boshoff and Currie (1981). It is clearly longer than the figure given by Brown and Amadon (1968) and McLachlan and Liversidge (1978). Regression equations that compare female weight with incubation periods in a range of raptors (Newton 1979) allow for comparison here: using weights of 8 and 8.5 kg (Mundy 1982), incubation periods of 55 and 56 d are predicted.

Nestling period. — Immediately after hatching, both parents usually remained at the nest together for longer periods than during incubation. Nestlings were guarded most of the time by at least one parent (Mundy 1982; this study), unlike other vulture species (Pennycuik 1976; Munday 1982). Predation may account for a substantial portion of egg and nestling loss in colonies, e.g., gulls, reviewed by Hunt and Hunt (1976). The high parental attendance by Cape Vultures, following the period after the nestling is dorsally feathered (and capable of thermoregulation), could reflect an anti-predator response. Mundy (1982) suggested it was an effect of coloniality and the traffic of strangers to the nest. The ability of parents to repulse Black Eagle (*Aquila verreauxi*) predatory attempts is enhanced by their colonial nesting habit (Mundy et al. in press).

That attentive periods of both sexes were shorter than during the incubation period reflects the increased attendance of both parents, as well as less intensive attendance by any one parent. This made changeovers more difficult to discern and resulted in a greater proportion of "within-day" attentive periods being recorded. The earlier changeover time probably reflects the earlier sunrise of approaching summer.

Nestlings of the Lappet-faced Vulture (*Torgos tracheliotus*) are paratized by hippoboscids flies (*Icosta meda*) (Anthony 1976), and in 1981 Potberg nestlings were heavily infested with simuliid flies. Because parents remove flies, the number of flies that I observed was probably greater than it would have been had I not disturbed the parents. The degree of nestling infestation is related to preceding rain as indicated in Fig. 5, although other factors may influence their presence.

Simuliids are known to be vectors of protozoan parasites (Fallis et al. 1973), and are likely vectors of avian haematozoa (Boshoff 1981; Boshoff and Currie 1981). Blood smears of 1979 nestlings (a year of heavy infestation) contained one or more

species of *Leucocytozoon*, the degree of infection varying (Boshoff and Currie 1981). The early blood film taken from a 22-d-old nestling revealed no *Leucocytozoon* presence probably because of aspects of the fly's life cycle: gametocytes of *L. neavei* were first seen in peripheral blood of Helmeted Guineafowl (*Numida meleagris*) nestlings 14 d after infection from sporozoites (Fallis et al. 1973). The subsequent fledging success of those Potberg nestlings is unknown, thus, whether *Leucocytozoon* contributes to Cape Vulture mortality or morbidity remains undetermined. A nestling that exhibited low *Leucocytozoon* infection (and which was fed on by a large number of simuliids) was last seen flying 6 d after it fledged, and it did not have a post-fledging dependence period. Given the necessity of at least some supplementary aid from parents during this period (Robertson 1985), even if it dispersed, the chances are that it did not live long. However, no link between its probable death and parasitaemia is suggested; the nestling certainly lived for about 3 mo with this infection. More observations of the fate of nestlings infected with blood parasites are needed before effects of either parasite can be determined. Adults remove flies with their bills, suggesting that they are behaviourally adapted to their parasites (Markus 1974). In a previous study of haematozoa from southern African vultures, the Cape Vulture was the only species not infected with blood parasites (Greiner & Mundy 1979). This was ascribed to its unique nesting habit as well as the timing of its breeding season. In their first few weeks of life, nestlings have a relatively soft skin and are either naked or sparsely covered with feathers; consequently it is at this stage they are most vulnerable to biting insects (Markus 1974). Greiner and Mundy (1979:152) sampled nestlings from summer-rainfall colonies, during which time "appropriate ornithophilic vectors are evidently scarce or absent . . . precluding transmission of potential pathogens . . ." Simuliid flies require water in which to breed (Ledger 1979), and the stream in the ravine provides suitable habitat. The Potberg colony is the only one I know of with a suitable breeding ground for these flies within 400m of the breeding ledges (see Mundy 1982; Tarboton and Allan 1984).

The length of the nestling period, although variable between years, is also closely predicted by Newton's (1979) regression equation: 141-148 d for body masses of 8 and 8.5 kg.

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ATTACKS BY BLACK EAGLES ON VULTURES

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ABSTRACT - Numerous attacks by the Black Eagle (*Aquila verreauxi*) on vultures were observed. While only once was an eagle seen eating a vulture nestling, many other attacks by eagles on the nestlings and eggs of the Cape Griffon Vulture (*Gyps coprotheres*) were interpreted as predation attempts. The vulture recognizes the eagle as a predator, and the plumage and behavior of feathered nestlings possibly have a camouflage function. Eagles also attack flying vultures, but these instances are probably territory defense.

The Black (Verreaux's) Eagle (*Aquila verreauxi*) is a cliff and mountain dwelling raptor that preys largely on the Dassie (Order Hyracoidea), which are compact tail-less mammals up to 5 kg in wt. In the Matopos area of Zimbabwe, for example, where the eagle has been intensively studied for 20 yrs, 98.5% of more than 2,000 prey items were of two species of dassie (Gargett 1980). In other areas a greater variety of prey has been recorded including birds, and particularly gamebirds, but Brown and Amadon (1968) suggested that all prey is "taken on the ground." The Black Eagle also readily feeds on carrion (Steyn 1982).

Having studied vultures around southern Africa for some years, we are impressed by the number of interactions that we have seen between Black Eagles and vultures. Always the eagle has initiated an encounter; sometimes the vulture has reacted to the eagle (a true interaction) and at other times it has not. Because the Black Eagle inhabits the same mountainous areas as does the Cape Griffon Vulture (*Gyps coprotheres*), all but one of the encounters we have seen were between these species. We detail our observations here, and review others from the literature.

OBSERVATIONS

All nine colonies of Cape Griffon Vultures that we have studied are contained within the territories of Black Eagles. Thus the paired eagles have daily access to vultures, and on many occasions we have seen one or both eagles, and occasionally the juvenile, fly into the vulture colony and attack birds at a nest. Thirteen of these incidents are listed in Table 1, and 11 were directed at a nest with a nestling; five attacks were successful, in that the nestlings were removed from their nests. Six attacks on nestlings were unsuccessful, as were two directed at a nest with an egg. In some instances, the nestlings were described as downy or feathered; the eagle flew off with a downy chick in its foot on three

occasions, but knocked the feathered nestling out of its nest and thus onto the ground. In this latter instance the eagle flew down with the falling nestling and remained with it on the ground, but did not actually feed on it. The two adults listed in incident no. 13 (Table 1) possibly worked in cooperation, for one eagle harassed the vulture which, in rearing up in threat posture, kicked its downy nestling out of the nest, whereupon the second eagle flew in and grabbed it. Such cooperation has also been suggested by Bowen (1970).

Incident no. 14 in Table 1 deserves separate comment. The Gonarezhou National Park in the southeast corner of Zimbabwe is a savanna wildlife area. In the whole Park there is only one stretch of cliffs, and one pair of Black Eagles nests on them. At 0700 H one morning, an adult was seen in the nest of a pair of White-headed Vultures (*Trigonoceps occipitalis*) eating the nestling, which was just becoming feathered (but had been plucked) and was estimated to be 50 d of age from its wing length (Mundy 1982). The eagle was presumed to have killed the nestling, as the carcass was very fresh and there were signs of hemorrhaging on the downy feathers and on some of the bones; unfortunately it was not noticed if there was any subcutaneous hemorrhage. The distance between the eagle's nest on the cliffs and the vulture's nest in the savanna country was 10 km. This is the only incident when we have seen the eagle actually eating a vulture nestling.

In addition to the 14 attacks on nestlings and eggs that are listed in Table 1, we have also collected three "contacts" by Black Eagle on Cape Griffon Vultures and one on a Bearded Vulture (*Gypaetus barbatus*) (Table 2). The eagle may or may not harass a vulture on the cliff, but then flies after it and strikes it in mid-air. For incident no. 1 (Table 2), the vulture was knocked to the ground and it died (Pitman 1960). For incident no. 4, the eagle flew after a group of vultures for an estimated 2 km, and for no apparent reason struck one in mid-air and

Table 1. Attacks (presumed predatory attempts) by Black Eagles on vulture eggs and nestlings.

DATE	PLACE ^a	TARGET ^b	BLACK EAGLES	RESULT ^c	OBSERVER
1. —	Magaliesberg, SA	CGV eyas	2 adults	S	Bowen (1970)
2. —	Mannyanonong, B	CGV eyas (d) ^d	—	S	Steyn (1973)
3. June 1974	Magaliesberg, SA	CGV egg	1 juvenile	U	P J M
4. September 1980	Langeberg, SA	CGV eyas	2 adults	U	Boshoff (1981).
5. September 1980	Langeberg, SA	CGV eyas	1 adult	U	Boshoff (1981).
6. September 1980	Langeberg, SA	CGV eyas	1 adult	U	Boshoff (1981).
7. October 1980	Kransberg, SA	CGV eyas (p)	1 subadult	S	T O'C
8. July 1981	Potberg, SA	CGV egg	1 subadult	U	A S R
9. December 1981	Potberg, SA	CGV eyas (p)	2 adults	U	A S R
10. December 1981	Potberg, SA	CGV eyas (p)	1 adult	U	A S R
11. January 1982	Potberg, SA	CGV eyas (p)	1 juvenile	U	A S R
12. July 1982	Magaliesberg, SA	CGV eyas (d)	1 adult	S	J K
13. July 1982	Magaliesberg, SA	CGV eyas (d)	2 adults	S	J K
14. October 1982	Gonarezhou, Z	WHV eyas (p)	1 adult	S	P J M

^a Places are Botswana (B), South Africa (SA), and Zimbabwe (Z).

^b Target species are Cape Griffon Vulture (CGV), and White-headed Vulture (WHV).

^c Results are successful (S) for the eagle, or unsuccessful (U).

^d Vulture nestlings were sometimes recorded as feathered (p) or downy (d).

caused it to tumble; the vulture continued flying, and the eagle flew away from it. For the incident with the Bearded Vulture, where both adult eagles were involved, it seems that the eagles may have been defending their nesting area.

DISCUSSION

The Black Eagle is said to be an "opportunistic" hunter that takes whatever may be available to it (V. Gargett *in litt.*). Those eagles that live with a colony

Table 2. Attacks by Black Eagles on flying vultures (with abbreviations as for Table 1).

DATE	PLACE ^a	TARGET ^b	BLACK EAGLES	RESULT	OBSERVER
1. December 1958	Mannyanonong, B	CGV	1 adult	CGV killed	Pitman (1960)
2. - 1980	Drakensberg, SA	BV immature	2 adults	BV "limping"	Damp (1980)
3. December 1981	Potberg, SA	CGV adult	1 adult	no contact	A S R
4. May 1983	Magaliesberg, SA	CGV	1 adult	CGV unharmed	P J M

^a Places are Botswana (B) and South Africa (SA).

^b Target species are Cape Griffon Vulture (CGV) and Bearded Vulture (VB).

of vultures certainly attack nestlings (and eggs) and flying vultures. While we have seen an eagle actually eat a vulture nestling only once, we have seen eagles remove nestlings several times and have seen the birds thwarted at their attempts at other times. We regard these attacks on nestlings (and eggs) as attempted predation. In contrast, the attacks by the Black Eagle on flying vultures are likely to be territorial encounters, even though in one instance the vulture was knocked to the ground. Pitman (1960) called this incident "predation," but we do not regard it as such as the eagle did not follow the vulture to the ground.

Downy vulture nestlings weigh less than 3 kg, and can be carried by an eagle, but feathered ones are likely to be too heavy and certainly too unwieldy; these can be knocked to the ground. Eagles pluck their prey, and the White-headed Vulture nestling was also plucked in the nest. In addition, at the foot of cliffs where Cape Griffon Vultures breed we have often found piles of feathers plucked from nestlings; we suggest that these are the result of eagle attacks and that they represent true predation. Vulture nestlings may fall out of their nests and be scavenged by mammals such as Jackals (*Canis* spp.) and the Porcupine (*Hystrix africaeustralis*), but these do not pluck prey or carrion.

Black Eagles breed from April to June, and the young fledge in August to October (Steyn 1982); the Cape Griffon Vulture breeds at the same time but its young fledge in October to December. Thus the eagle has a potential food supply throughout its breeding season, and Table 1 shows that the eagle takes the opportunity throughout that period. (The lack of observations from February through April are due both to there being no vulture nestlings at this time, and also because these months are in the rains when observations are more difficult to make). We have visited an eagle nest in a vulture colony only once, in the Magaliesberg in September 1976, and no vulture remains were found. Nor do we know of any instance where vulture remains have been found in Black Eagle nests, though eagles in vulture colonies have not been studied in this respect (Allan 1984).

The Black Eagle and the White-headed Vulture do not overlap in their nesting niches, and do not compete for any resources as far as is known. We regard the predation incident as described above (no. 14 in Table 1) as most unusual, and do not think that the eagle is of any significance in the life

of this vulture. By contrast, the Black Eagle must be regarded as a capable and perhaps frequent predator of the nestlings of the Cape Griffon Vulture simply because the two species occupy the same nesting niche. The observations of unsuccessful attacks by the eagle, however, where it has been repelled by the vultures, highlight one of the advantages associated with colonial breeding. That is, a clumped group of nesting vultures with each parent involved in chasing away a potential predator from its nest, results in an increased repulsion effect. The Black Eagle is certainly seen by the Cape Griffon Vulture as a threat, and the vulture has a characteristic and hoarse call that is directed at an eagle flying past the nest. Vulture nestlings of all ages are vulnerable to predation, which is perhaps why there is usually a parent in attendance throughout the nestling period (Mundy 1982). In addition, we suggest that the nestling plumage has a camouflage function, which is enhanced by the typical raptor reaction to disturbance or to intruders of crouching motionless and facing into the cliff wall (Fig. 1). The plumage of the nestling is streaked. In color it is creamy-white dorsally, the flight feathers are a dark slate, and the last row of upper-wing coverts (i.e., the greater coverts) are pointed with a conspicuous white tip (Fig. 1). When the feathered nestling crouches the visual impression is one of an accumulation of white mutes trickling down a dark rock. Feathered nestlings of the Rüppell's Griffon (*G. rueppellii*) have the same



Figure 1. A well-feathered Cape Vulture nestling, aged about 11 weeks.

coloration and patterning as do those of the Cape Griffon Vulture (pers. obs.), and this species may also live with the Black Eagle.

The vulnerability of vulture eggs and nestlings to predation by the Black Eagle, incidentally, is increased if the parent birds are disturbed on their ledges, and man-induced disturbance should therefore be kept to a minimum.

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THE BEHAVIORAL RESPONSE OF A RED-TAILED HAWK TO MILITARY TRAINING ACTIVITY

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Abstract — From 13 August through 9 November 1982, we systematically radio-tracked an adult male Red-tailed Hawk (*Buteo jamaicensis*) on the Fort Carson Military Reservation in east-central Colorado. Harmonic mean analysis of telemetry data indicated that the bird shifted its center of activity away from areas of high human activity, but returned to those areas after human activity ceased.

Both short and long term effects of human disturbance on birds of prey have been the subject of recent investigation. Changes in density and species composition (Voous 1977; Craighead and Mindell 1981) and in population size and nesting distribution (Swenson 1979) have all been attributed to increased human activity. Nesting failures (Boeker and Ray 1971), lowered nesting success (Wiley 1975), and impacts on wintering distribution and behavior (Stalmaster and Newman 1978) have also occurred as a result of increased human activity. Activities of short duration, however, have not had

as great an impact. Helicopter overflights (Platt 1977), frequent low level jet overflights (Snyder et al. 1978), and jet flights with associated sonic booms (Ellis 1977) did not appear to limit productivity or adversely affect behavior in a variety of North American raptors. Jackson and McDaniel (1977) even observed a Northern Harrier (*Circus cyaneus*) they believed exploited military activity to increase hunting success. Here, we report on behavioral responses of an adult Red-tailed Hawk (*Buteo jamaicensis*) to periodic military training activity.

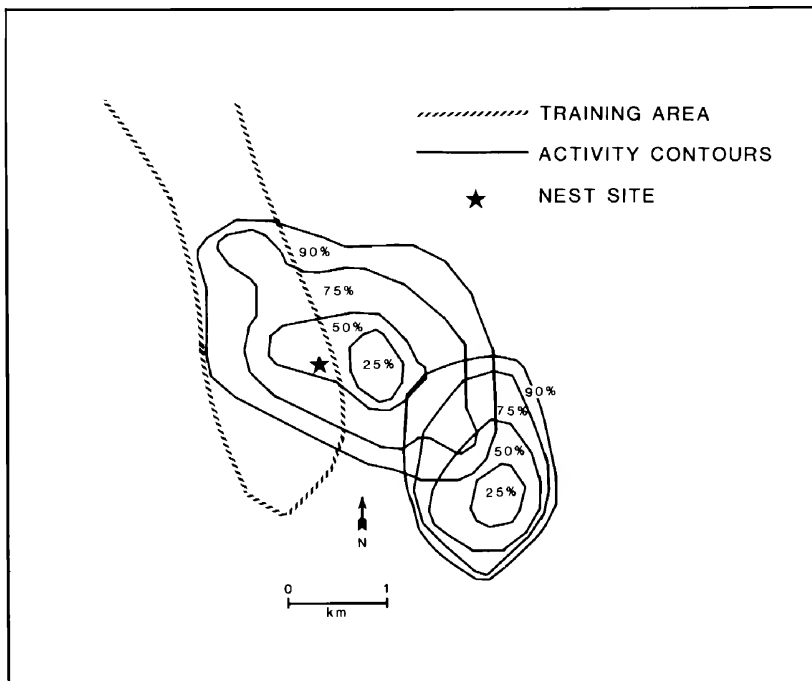


Figure 1. Activity areas of an adult male Red-tailed Hawk on the Fort Carson Military Reservation, Colorado, from 13 August through 9 November 1982. Activity contours represent isopleths that enclose 25, 50, 75 and 90% of all relocations. The larger area was calculated from 74 relocations obtained when there was no military activity in the training area, and the smaller area was calculated from 31 relocations obtained when the training area was used for tank maneuvers and heavy weapons firing.

Table 1. Tracking periods on an adult male Red-tailed Hawk at Fort Carson Military Reservation, Colorado, from 13 August to 9 November 1982.

DATE	NUMBER OF RELOCATIONS	HOURS TRACKED	MILITARY ACTIVITY ¹
13 August	9	4.0	none
25 August	6	3.0	none
26 August	3	1.0	none
31 August	9	4.0	present
13 September	7	3.0	none
14 September	8	3.5	none
20 September	9	4.0	none
26 September	7	3.5	none
3 October	8	3.5	none
12 October	9	4.0	present
20 October	8	3.5	none
27 October	7	3.0	none
2 November	2	2.0	none
5 November	5	2.0	present
9 November	8	3.5	present
Totals	105	47.5	

¹Refers to the activity level in the tank training area (see text). Military personnel and equipment were either training in ("present") or absent from ("none") the area.

STUDY AREA AND METHODS

The Fort Carson Military Reservation is in east-central Colorado along the eastern edge of the Front Range south of Colorado Springs, Colorado. Climate there is classified as dry continental and major plant associations include pinyon pine (*Pinus edulis*) - juniper (*Juniperus monosperma*), blue grama (*Bouteloua gracilis*) - western wheatgrass (*Agropyron smithii*), and cottonwood (*Populus* spp.) - willow (*Salix* spp.) (Harrington 1954; U.S. Army 1980). Elevation is approximately 1700 m and topography is characterized by moderately rolling high plains whose surfaces are often interrupted by scattered rocky escarpments and low foothills. The study area is used by the U.S. Army for the training, housing and support of the 4th Infantry Division (Mechanized).

On 31 May 1982, we captured an adult male (sex was determined by behavior and relative size) Red-tailed Hawk and fitted it with a radio transmitter attached as a backpack (Smith and Gilbert 1981). The bird's nest was situated on a cliff immediately adjacent to a military training area (Fig. 1) in a 1-3 km wide valley. One young fledged from the nest in late June. The training area was used periodically during the study for tank maneuvers and heavy artillery firing. When in use, approximately 50 tanks were in the area and periodic firing occurred at stationary and moving targets. Vehicles and military personnel used the entire valley, and a major vehicle trail passed 250 m in front of the nest cliff. The primary firing area was 500 m south of the nest site and tanks fired from this area past the nest cliff at targets either in the valley or in an impact area 11 km to the north.

We monitored the bird for 47.5 hrs between 13 August and 9 November 1982. Relocations were obtained every 30 min during 2 to 4 hr tracking periods and plotted on 1:24,000 U.S. Geol. Survey topographic maps. Tracking was conducted from a vehicle and on foot. Military activity was assessed visually throughout each tracking period and categorized on the basis of presence or absence of military personnel and equipment. Four tracking periods occurred when the training area was being used by the military, and 11 periods occurred when it was not (Table 1).

We calculated minimum perimeter polygons (Mohr 1947; Jennrich and Turner 1969) for periods during military activity and for periods when the training area was not in use. Harmonic mean measures of activity areas (Dixon and Chapman 1980) were used to assess behavioral responses to military activity. Arbitrary 10 x 10 grids were selected for calculating harmonic means in a computer program developed by J.R. Cary at the University of Wisconsin.

RESULTS AND DISCUSSION

During periods when there was no military activity in the tank training area, the adult male Red-tailed Hawk included much of the training area within its activity area (Fig. 1). Twenty-five of 74 (34%) total relocations were obtained within the boundaries of the training area and 37% of the 90%

harmonic mean activity area was included in the training area. In contrast, during periods of military activity, none of the 31 relocations obtained were inside the training area and the bird shifted its center of activity approximately 1.75 km southeast (Fig. 1). During these periods, the bird was never located west of the ridge which defined the east boundary of the training area. This north-south oriented ridge supported the nest and visually isolated the training area from the bird's southeast activity area.

Minimum perimeter polygons also showed a shift to the southeast during periods of military training. The minimum perimeter polygon calculated for periods of army activity defined an area of 219 ha in the southeast portion of the bird's range. Thirty percent (75 ha) of this area was outside of the minimum perimeter polygon (790 ha) defined by relocations obtained when there was no military activity in the training area. Harmonic mean analysis of all relocations obtained for the bird (combining data collected during periods of army activity and periods of no activity) showed the same 2 activity centers as those generated when data were separated on the basis of military activity.

The adult male hawk apparently altered its behavior to accommodate periods of military activity. It was never relocated in the training area when military personnel and equipment were present, although it returned to the training area after training ceased. The bird's mate was not marked, and we did not determine whether it exhibited similar behavior. Since the pair nested within the confines of the training area, and since most Red-tailed Hawks are year-round residents on the study area (Andersen 1984), the male had probably been exposed previously to periods of intensive military activity. We do not know how frequently this short term displacement/relocation behavior may occur in Red-tailed Hawks or whether it is also exhibited by other birds of prey.

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Habitat Use by Wintering Golden Eagles and Rough-Legged Hawks In Southeastern Idaho

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Little information is available on winter habitat preferences of raptors, even though they spend nearly as much time in wintering areas as nesting areas. Wilkinson and Debban (1980) identified a need for determining habitat preferences for wintering raptors so that effects of habitat alterations on raptor populations might be predicted. This may be especially important where native habitat is being altered to increase grazing, or for agricultural lands in the intermountain west. The purpose of this study was

to identify wintering habitats used by the Golden Eagle (*Aquila chrysaetos*) and Rough-legged Hawk (*Buteo lagopus*) on and around the Idaho National Engineering Laboratory (INEL) in southeastern Idaho.

During 1981-1982, we conducted a daytime winter inventory (30 November - 23 February) of raptors on INEL. During the recent inventory (7 surveys), we plotted the specific location of 626 Rough-legged Hawks and 283 Golden Eagles on vegetation maps of the INEL (McBride

Table 1. Habitat comparisons for wintering Golden Eagles and Rough-legged Hawks observed in various habitat types on a 1981-1982 car survey in southeastern Idaho. Chi-square values are indicated in parentheses.

HABITAT ^a	GOLDEN EAGLE OBSERVED ^b	EXPECTED ^b	ROUGH-LEGGED HAWK OBSERVED ^b
<i>Artemesia tridentata</i> - grass	32.1 (1.048) ^h	29.1	10.9 (71.67) ^c
<i>A. tridentata</i> - grass (no power poles)	9.9 (21.03) ^c	22.9	4.2 (96.07) ^c
<i>A. tridentata</i> - <i>Certoides lanata</i>	29.0 (49.28) ^e	13.6	11.3 (2.59) ^g
<i>Juniperus osteosperma</i> - <i>A. tridentata</i> - grass	5.3 (53.29) ^e	1.0	1.6 (2.59) ^g
Agricultural Land	4.2 (8.14) ^f	9.4	63.1 (1924.90) ^c
<i>Chrysothamnus viscidiflorus</i> - grass - <i>Opuntia polycantha</i>	3.5 (0.82) ⁱ	3.1	1.9 (2.59) ^g
<i>Tetradymia canescens</i> - <i>C. viscidiflorus</i> - <i>A. tridentata</i> (no power poles)	2.5 (9.19) ^f	7.3	3.8 (12.89) ^c
<i>Agropyron cristatum</i> (no power poles)	2.1 (5.28) ^c	5.2	0.5 (29.46) ^c
<i>Atriplex nuttallii</i> - <i>C. lanata</i> - grass	1.8 (0.82) ⁱ	2.1	2.0 (2.59) ^g
<i>Artemesia arbuscula</i> - <i>Atriplex confertifolia</i> - grass	1.4 (0.82) ⁱ	1.0	0.2 (7.05) ^d
<i>A. tridentata</i> - <i>A. arbuscula</i> - <i>Atriplex confertifolia</i>	8.1 (23.04) ^e	3.1	0.5 (16.45) ^c

^aPower poles were present in all sections unless noted otherwise.

^bPercent of total birds seen rounded to nearest tenth of a percent.

^cP < 0.025; ^dP < 0.001; ^eP < 0.001; ^fP < 0.005; ^gP > 0.05; ^hP > 0.25; ⁱP > 0.75.

et al. 1978). The frequency of raptor occurrences per habitat was compared to expected frequencies of both species in each habitat type (Chi-square (χ^2) test). The expected frequencies were determined by multiplying the total number of each species observed per survey by percent occurrence of each habitat along the 187 km survey route. The percent habitat coverage was determined by selecting 95 random points on a map of the survey route and calculating the percent of points which fell in each habitat type (after Marcum and Loftsgaarden 1980). All agricultural lands, usually alfalfa (*Medicago sativa*) and grain fields, were considered one habitat. Areas where few or no power poles were available for perches were listed separately, since Craig (1978) reported that both Golden Eagles and Rough-legged Hawks showed a preference for power poles as perch sites on INEL.

Golden Eagles occurred in agricultural areas significantly less often than expected ($P < 0.005$; $\chi^2 = 8.1422$; Table 1) and were found most frequently in certain habitats dominated by native vegetation (Table 1). However, 3 areas covered with native vegetation or *Agropyron cristatum*, but containing few or no powerlines were used significantly less often ($P < 0.01$, $\chi^2 = 1.0482$; $P < 0.005$, $\chi^2 = 9.194$; $P < 0.025$, $\chi^2 = 5.2776$; Table 1) than expected by Golden Eagles. Birds either selected preferred habitats where perches were available, or birds were more visible when perched. These findings are similar to those of Fischer et al. (1984) in Utah. Golden Eagles occurred most often in areas where winterfat (*Ceratoides lanata*), grass and shrub species such as Utah juniper (*Juniperus osteosperma*) and big sagebrush (*Artemisia tridentata*) predominated. Johnson (1982) observed that shrubby habitats are used for cover during the daytime by Black-tailed Jackrabbit (*Lepus californicus*) and that winterfat and some species of grass comprised most of the hares' diet. Gross et al. (1974) found higher densities of jackrabbits in sagebrush habitats than in croplands, and Johnson (1982) seldom found them in open areas of native habitat during the day. Therefore, the areas where eagles were most frequently observed may have contained higher numbers of jackrabbits, an important prey of Golden Eagles (Smith and Murphy 1979; Thompson et al. 1982).

Rough-legged Hawks were observed in farmland areas significantly more often ($P < 0.001$; $\chi^2 = 1924.9$; Table 1) than expected in most other areas (see also Fischer et al. 1984). Since these hawks feed largely on small mammals (Craighead and Craighead 1956), they would likely occur in areas where such animals are abundant. Watson (1983) found that the major prey of Rough-legged Hawks in the agricultural land of our study areas was *Microtus montanus*. In southwestern Idaho, *Microtus* spp. are more numerous near agricultural lands than in desert areas (Marks and Yensen 1980). This is probably also true on our study area and would thus account for the distribution of these hawks. As with Golden Eagles, significantly fewer ($P < 0.001$; $\chi^2 = 96.0174$; $P < 0.001$, $\chi^2 = 12.8900$; $P < 0.001$;

$\chi^2 = 29.4622$; Table 1) Rough-legged Hawks were observed in areas lacking power poles; however, other native habitats also hosted fewer hawks than expected.

In conclusion, Golden Eagles were observed most frequently in certain parts of the INEL study area covered with native shrub-steppe vegetation and significantly less often ($P < 0.005$; $\chi^2 = 8.1422$; Table 1) in farmland. In contrast, Rough-legged Hawks were sighted more often in agricultural areas. The distribution of these raptors may have resulted because of the prey species associated with the 2 different habitats. Fleming (1981) also noted that Rough-legged Hawks occurred primarily in agricultural areas and Golden Eagles in areas of native vegetation in southeastern Washington. Our results suggest that the native shrub-steppe habitats in Idaho are important as wintering habitat for Golden Eagles. Alterations of this habitat may adversely affect the wintering Golden Eagle population but may favor wintering Rough-legged Hawks, if the habitat alterations benefit small mammal populations.

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Distribution and Density of Prairie Falcons Nesting in California During the 1970s

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The Prairie Falcon (*Falco mexicanus*) is endemic to western North America, and although extensively studied, questions still remain regarding distribution of nesting territories and density throughout its range. Information on Prairie Falcon nest site distribution and densities in California was limited prior to 1970. Grinnell and Miller (1944:108) stated that Prairie Falcons were "extensive throughout the state save in northwest humid coast belt. Metropolis appears to lie in southeastern desert and thence northwest along inner coast ranges." Miller (1951) used 3 methods to analyze California avifaunal distribution — life zone, biome, and biotic province — but did not specifically examine the distribution of Prairie Falcons statewide based on vegetational schemes. In 1971 the California Department of Fish and Game began a two-year statewide survey of Prairie Falcon nesting sites (Garrett and Mitchell 1972) that yielded comprehensive distribution data and provided impetus for more surveys. Here we report on Prairie Falcon nesting distribution and densities in California, and on the unusually low nesting density in northwestern California that *may be* the result of (1) interspecific competition with increasing numbers of Peregrine Falcons (*Falco peregrinus*), and/or (2) the presence of unsuitable foraging habitat.

Garrett and Mitchell (1973) provided us with 256 nesting territory locations that were originally obtained from ornithologists, egg collectors, museums, falconers, state and federal biologists and personal records. A territory was defined as an area 1 km in diameter that may have one or more alternate nest sites located within it. The existence of a territory was confirmed when (1) a pair of adults was found defending a specific location during the nesting season, (2) adults were observed incubating or brooding young in or on a ledge-pothole-cavity-or stick nest, (3)

when young were observed at a nesting site or (4) when recently fledged young in family groups were located. A territory was "active" when any of the aforementioned criteria were observed in subsequent years and inactive if falcons were not found. Visits to territories in following years revealed that alternate nest locations were sometimes used. When Prairie Falcons shifted nest site locations within the original 1 km diameter area of the territory we treated the nest as being within the same territory if no other Prairie Falcons were present within 1 km of the nest. Infrequently, two or more pairs of Prairie Falcons nested simultaneously within 1 km of each other and 1 km territories overlapped.

We added to Garrett and Mitchell's data base during the 1970s by conducting surveys, during the nesting season, of potential nesting areas using helicopters (after 1976), automobiles, motorcycles and by searching on foot. Additional records of Prairie Falcon nesting territories were obtained from the California Department of Fish and Game and other biologists working for state and federal agencies. Territories were plotted on U.S.G.S. topographical maps (1:64,000) and deposited with the Western Foundation of Vertebrate Zoology, Los Angeles, California.

The entire state was examined during the 1970s (1970-1979) for nesting Prairie Falcons. Our original intent was never to locate every single territory in the state. However, as we worked during the 1970s we were able to cover the entire state in great depth. We were not able to examine (in depth) the entire state in any single year and we did not have the manpower to visit all known territories in a single year. Furthermore, even with the use of helicopters, we could not be certain that we located all territories within every habitat type visited as Prairie Fal-

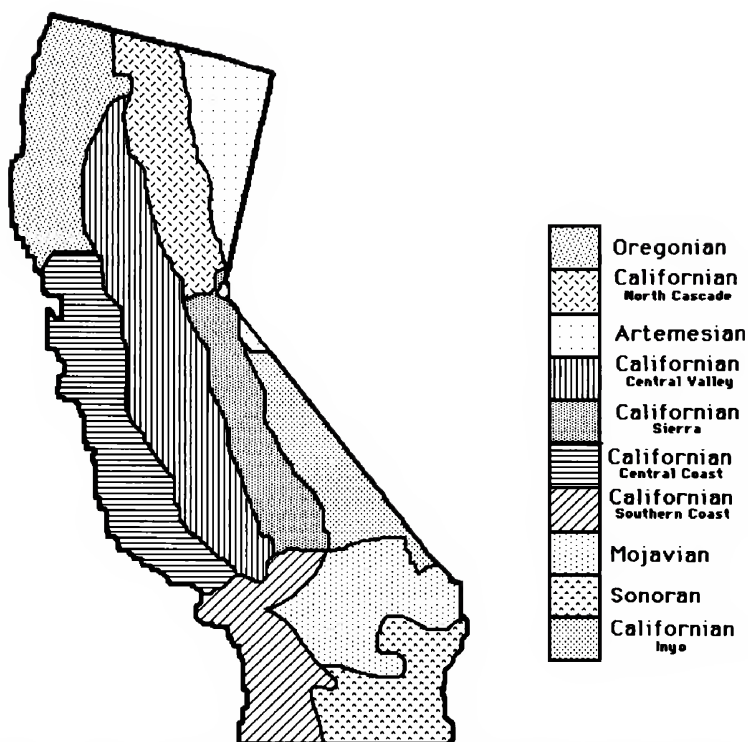


Figure 1. Biotic provinces of California (after Dice 1943). Within the Californian Province floristic regions are designated (after Stebbins and Major 1965).

cons were not always present at each territory every year. Although our nesting densities were not absolute (i.e., conservative estimates because of variable sampling intensities), they do provide for meaningful density comparisons by biotic province. We examined new areas each year and reexamined areas previously covered until the end of the 1970s. Our search image for nests was biased in that we examined only geologic formations for nesting pairs. We did not attempt to locate tree-nesting falcons (MacLaren et al. 1984) or falcons nesting on man-made structures (Boyce et al. 1980). We examined all territories reported on here at least once during the 1970s.

We report our findings by biotic province (Dice 1943, Fig. 1), which is similar to the U.S. Forest Service's ecoregions of the United States (Bailey 1980). Biotic provinces are delineated for all of North America and provide a means for researchers to report future comparative densities for the remaining biotic provinces. We subdivided the California Province, because of its recognized floristic heterogeneity, and reported nesting densities within it by floristic region (Stebbins and Major 1965). The number of territories reported for each area is the maximum count made during the entire study period.

Prairie Falcon nesting territories were distributed unevenly throughout California, but the mechanism(s)

causing the uneven distribution remains unknown (Table 1). More than 1,250 nesting attempts were observed at 520 nesting territories during the 1970s. The greatest number of active territories observed in a single year was 300 in 1977. During 1977, only 60% of the known territories were visited. Based on the number of territories found active in 1977, we estimate between 300-500 breeding attempts may occur annually within the state. Garrett and Mitchell (1973) provide data that showed an average of 2.18 fledglings were produced per pair studied statewide for a 3-year period. Based on 300-500 pairs of falcons attempting to nest each year, we estimate that between 650 and 1,100 fledgling falcons may be produced annually in California.

Greatest densities of nesting Prairie Falcons were found in the Mojavian Province (Mojave Desert) and central coast of the Californian Province (Table 1). During the latter part of the 1970s, historical nesting territory occupancy rates and fledgling productivity rates for the Mojave Desert were down (Boyce 1982) from those observed earlier by Garrett and Mitchell (1973). In contrast, the central coast population experienced an increase in number of occupied territories during the 1970s (Garrett and Walton unpub. data). The major difference between the two areas was that the Mojave Desert remained in

Table 1. The distribution and density of Prairie Falcon nesting territories in California by biotic province (shown bold; Dice 1943). Distribution and density of nesting territories by floristic region (Stebbins and Major 1965) within the Californian province are given.

BIOTIC PROVINCE	NESTING TERRITORIES (PER BIOTIC PROVINCE)	AREA (KM ²)	KM ² /TERRITORY
Mojavian	91	23,210	255
Artemisian	63	22,600	359
Californian	332	267,080	804
Central Coast	136	47,920	352
Central Valley	78	59,390	761
Inyo	39	34,520	885
Southern Coast	44	47,500	1,080
Cascade/N.Coast	30	34,370	1,146
Sierra	5	43,380	8,676
Sonoran	25	29,450	1,178
Oregonian	9	55,000	6,111
TOTALS	520	397,340	764

public ownership (U.S. Bureau of Land Management) while the central coast remained in private ownership. Land use policies differ drastically between the two areas. Private land owners in the central coast prevented high levels of human disturbance from occurring. In contrast, the Bureau of Land Management's multiple land use philosophy for the Mojave Desert resulted in nesting Prairie Falcons being subjected to tremendous human disturbance, and fledgling productivity rates were significantly lower for nests located near roads versus nests away from roads (Boyce 1982).

Northwestern California (west of longitude 123) had the lowest nesting density within the state despite an abundance of cliffs. Data suggest their absence in northwestern California *may be* due in part to interspecific competition with Peregrine Falcons for nest sites and lack of suitable foraging habitat. Walton (1978) observed two adult peregrines attack and apparently kill a Prairie Falcon flying near the peregrines' nest site in northwestern California. Northwestern California contained the greatest density of nesting peregrines remaining in the state and, during our study, their density slowly increased as the population recovered from presumed DDE poisoning (Monk 1981). However, interspecific competition for nest sites may not be important throughout the state. Dixon and Bond (1937) reported that Prairie and Peregrine Falcons nested concurrently on the same cliff near Tule Lake in northeastern California. We have also observed both species nesting in close proximity in other areas of the state. Presence of nesting peregrines and Prairie Falcons on the same cliff may be understood in

terms of habitat (no trees in sagebrush habitat) that apparently was conducive to hunting success of both species. At Tule Lake, Prairie Falcons primarily hunt ground squirrels (Haak 1983) while Peregrine Falcons probably captured exclusively birds.

Even where Peregrine Falcons were not occupying suitable cliffs (cliffs having ledges or potholes available) in northwestern California, Prairie Falcons were still absent. Unsuitable hunting habitat, in addition to interspecific competition, may have been a factor limiting Prairie Falcon densities since northwestern California is primarily forested with scattered open meadows. In northwestern California Peregrine Falcons often forage over forested valleys (Enderson and Kirven 1983) and river systems for avian prey that is attacked and captured in air (Hoddy pers. comm.). Prairie Falcons, on the other hand, generally hunt over unforested habitats for birds, mammals and reptiles, capturing prey mostly on or near the ground (15-100 m; Brown and Amadon 1968). In the Mojave Desert, Prairie Falcons have been observed to hunt, attack, and capture prey while within 10 m of the ground (Harmata et al. 1978; Boyce pers. obs.). The greatest nesting density of Prairie Falcons within California occurs in areas having few trees. Prairie Falcons, therefore, may be maladapted for exclusive predation on birds in forested habitat types.

Nesting densities and productivity rates have been reduced by urban sprawl in some areas (Boyce and Garrett 1977). Prairie Falcon distribution statewide, however, did not appear to be seriously affected during the 1970s, because (1) Prairie Falcons continued to occupy territories

that had a history of use in the last 30 years, (2) most territories studied by Garrett and Mitchell (1973) remained active until the end of the 1970s and, (3) during the later part of the 1970s we found additional territories in the same areas that had previously been examined.

Newton (1979) stated food or nest site availability set the upper limit of raptor pairs in an area. Undoubtedly, suitable habitat (unforested) with adequate nesting cliffs and ample vulnerable prey were fundamental factors involved in determining distribution and density of Prairie Falcons in California during the 1970s. Other factors possibly influencing Prairie Falcon distribution and abundance between and within biotic provinces were rainfall pattern and human population levels. We did not attempt to quantify cliff availability, prey availability or rainfall pattern and these were undoubtedly ultimate factors affecting distribution. There were definite differences in density of human populations in different areas. Northwestern California has few nesting Prairie Falcons and relatively low numbers of people. The Mojave Desert had high numbers of nesting falcons and low numbers of resident humans. However, an incredible number of recreationalists poured out of the megalopolis of Los Angeles and inundated the Mojave Desert during weekends, holidays and summer vacations. Lowered fledgling productivity in the Mojave Desert is attributed to high levels of human disturbance (Boyce 1982).

Prairie Falcons will occupy the same nesting territory year after year (not necessarily the same pair), but nest locations within territories may change. In some cases territories will remain unoccupied for 4-5 yrs in a row and then be reused. Data on nesting territory use through the years is important for; (1) determining the potential quality of individual territories by examining occupancy rates of territories between and within provinces, (2) examining use of alternate nests within the territory over time to determine critical habitat, (3) observing fledgling production through a series of years to determine levels of harvest or assessing population health, (4) observing how varying levels of human disturbance influence occupancy and reproduction and (5) assisting land managers in making informed decisions regarding land use practices.

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Bald Eagle Pursues and Injures Snow Goose in Flight

RICHARD S. BENNETT, JR., AND ERWIN E. KLAAS

The Bald Eagle (*Haliaeetus leucocephalus*) employs several hunting methods in capturing avian prey. They have been observed capturing waterfowl (Parris et al. 1980) and ptarmigan (Sherrod et al. 1977) on land by approaching close to the ground, and eagles also have been seen flying low between ocean swells, (White 1974) diving from a high altitude, (Meinertzhagen 1959; Sherrod et al. 1977) or returning to the surface from an underwater dive (Bent 1937; Munro 1938) to take sitting birds. All these methods depend on surprise and require little or no aerial pursuit. Brewster (1880) reported Bald Eagles capturing waterfowl, including wild geese in flight, by swooping under the prey, turning upside down, and grasping the breast of the prey with its talons.

Griffin et al. (1982) during 3 seasons of field work saw many attempts by Bald Eagles to kill apparently healthy waterfowl. Only 5 attempts were successful of which 1 capture was a Snow Goose (*Chen caerulescens caerulescens*). The authors give no details except to say the goose was forced down into a field and fed upon.

On 21 January 1983, we observed an adult Bald Eagle pursue and injure a Snow Goose near DeSoto National Wildlife Refuge located in Harrison County, Iowa, and Washington County, Nebraska. The weather was clear, with a temperature of about 2° C, a slight north wind, and the ground partly covered by snow.

At 1621 H, a flock of about 500 Snow Geese was flushed from the ice by a Bald Eagle near an open-water area on DeSoto Lake. The flock circled briefly and flew eastward from the refuge for several kilometers, evidently to feed in surrounding croplands. The geese flew in a typical searching pattern characterized by wide wavy lines, low altitude, and circling over prospective fields. About 1650 H, a Bald Eagle was observed following several hundred meters behind the flock at the same altitude. The flock then gained altitude and flew northwest along a nearly straight course at ground speeds in excess of 50 kph, as measured on our vehicle's speedometer.

The eagle continued to pursue and slowly gained on the flock for about 5 km. At about 1700 H, the eagle flew into the middle of the flock causing it to suddenly split into 2 groups. The lead group continued flying north while the trailing group briefly circled, as if confused, and then continued northward. At this point, the eagle pursued a single goose from the flock. On 3 occasions, the goose tried to dive below the eagle, but each time the eagle would also dive until it was below the goose and they would briefly fly horizontally. Finally the goose dove toward a wooded fencerow; however, the eagle dove and caught the goose during the vertical descent. Although it could not be determined how the eagle grasped the goose, both

birds fell and separated just before hitting the ground and glided into a corn stubble field about 1 km from the road.

As we approached the area on foot, we saw an adult Bald Eagle and an adult Snow Goose standing in alert postures about 10 m apart. The eagle flushed about 0.5 km from us, while the goose stood motionless until we were 10 m away. It then flew along the ground for about 0.5 km. As it flew, we saw blood over much of the rump area, especially posterior to the left wing. After relocating the goose, we again approached. It flushed at about 10-15 m and flew strongly toward the refuge lake about 4 km away. We believe the eagle would have eventually killed the goose on the ground, if we had not intervened.

Although we have been conducting field studies of Snow Geese in the fall since 1976, in the middle Missouri River valley, this was our first observation of such an extended pursuit of geese by an eagle. While Snow Goose flocks on water or land will invariably flush when an eagle flies overhead, the Canada Goose (*Branta canadensis*) and ducks rarely do. We have occasionally observed eagles pursuing individual Snow Geese for short distances after flushing feeding flocks from crop fields. In each instance, the goose escaped by diving into tall vegetation or outmaneuvering the eagle in flight. On the basis of the intense response of Snow Geese to flying eagles, predation may occur more often than our observations indicate.

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Osprey Captures Gray Squirrel

PETER TAYLOR

At approximately 0800 H on 6 February 1982, I saw an Osprey (*Pandion haliaetus*) capture an Eastern Gray Squirrel (*Sciurus carolinensis*) at Blue Springs State Recreation Area, near Orange City, Florida. Several squirrels were foraging on the ground, in and around a picnic site in a partly cleared area of live oak (*Quercus virginiana*) and unidentified palms adjoining the St. Johns River. Using 7x binoculars, I watched the Osprey glide in a shallow dive for about 100 m along a curving flight-path. It flew from the river over the clearing, snatched the squirrel from the ground without pausing, then flew back over the river, where it was lost to view behind trees.

The capture occurred about 100 m away; unfortunately, my view of the moment of capture was obscured by shrubbery, so I was unable to observe the reactions of the victim, or other squirrels, to the attack. The squirrel was grasped firmly in the Osprey's talons, and was immobile; I did not record whether it was carried in one or both feet.

Wiley and Lohrer (1973) reviewed records of non-fish prey taken by Ospreys. These included mammals as large as ground squirrels and rabbits, as well as a variety of birds, reptiles, amphibians and invertebrates. More recent instances of atypical prey have been reported by Castrale and McCall (1983), Kern (1976), Layher (1984) and Proctor (1977). This is apparently the first record of an Osprey taking a tree squirrel (albeit from the ground), and is one of rather few observations of the actual attack. It is unfortunate that the ultimate use of the squirrel could not be observed.

Wiley and Lohrer (1973) recorded at least 9 non-fish prey, mainly cotton rats (*Sigmodon hispidus*), taken by a pair of Ospreys near Tampa, Florida, in 1972. They suggested that some inland-nesting Ospreys might exploit an abundant alternative food source, since they are presented with more opportunities for non-fish prey while travelling between the nest and scattered bodies of water than are coastal-nesting Ospreys.

The incident described here took place alongside a large, clear river in mild, calm weather under a light overcast sky. The long, stealthy approach and adept capture by the Osprey suggests that this incident may have

been a regular feature of its hunting routine. These circumstances support the suggestion that some Ospreys take prey other than fish in an opportunistic manner, without the pressure of poor fishing conditions, inexperience, or other constraints on more typical hunting behavior.

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Adoption of a Juvenile by Breeding Spanish Imperial Eagles During the Postfledging Period

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Fostering and crossfostering of nestlings are management techniques that have been widely used in the field with different endangered raptor species (Meyburg 1977; Temple 1978; Olendorff et al. 1981). However, we know of only 2 published reports on adult breeding raptors feeding fledglings that were not their own (Ellis and Groat 1982; Poole 1982). Since this kind of adoption does not take place naturally in territorial species, these have probably not developed an intolerance of intruder fledglings (Wilson 1975). In this paper we describe the introduction of a fledged Spanish Imperial Eagle (*Aquila heliaca adalberti*) into a family group consisting of 2 adults and 2 young.

The experiment was carried out during a study of the post-fledging behavior of Spanish Imperial Eagles in the National Park of Doñana, SW Spain, during the summer of 1984. A young female fledgling that had lost its parents from electrocution was found starving on 31 July at 91 d of age and weighing 2300 g (the age of young was calculated from hatching dates). She was housed and fed for 9 days and reached a weight of 3550 g. Once recovered, the young female was released at an age of 100 d into the home-range of a family group with 2 young approxi-

mately 99 d of age and already out of the nest. Both the normal young and the introduced one were provided with radio-transmitters and wing-tags for visual identification. At the moment of release 2 dead rabbits were left near the young. Approximately 11 min after the fostered eaglet was released, she began feeding on one of the rabbits. She was soon joined by the 2 original young and all 3 fed together without obvious aggressive interactions. For the first 3 d after release, the fostered young remained perched near its stepbrothers. From the fourth day, it started to use the same perches as they did, being fed by the adults, without any evidence of rejection or aggression (Table 1). It seemed to be totally adopted, and followed the normal process of transition to independence. Unfortunately, on 19 August (age 109 d) one of the true young died in collision with an electric powerline. The data for this bird have been included in Table 1. Prior to dispersal, both the original and the adopted fledgling were fed and simultaneously chased by the adults (Table 1). Both made long distance flights on 30 August (age 120 d) and 16 September (age 138 d) respectively, and finally left on 1 September (age 122 d) and 20 September (age 142 d). Chasing consisted of stoops towards the young,

Table 1. Summary of feeding and chasing flights of adult Spanish Imperial Eagles towards young. The dates of final dispersal were 1 September for the original young and 20 September for the adopted young.

DATE	NO. OF FEEDINGS			NO. OF CHASING FLIGHTS BY ADULTS		
	ORIGINAL YOUNG A	ORIGINAL YOUNG B	ADOPTED YOUNG	ORIGINAL YOUNG A	ORIGINAL YOUNG B	ADOPTED YOUNG
11 August	2	0	1	0	0	0
18 August	0	1	0	12	0	2
19 August	0	0	0	0	0	0
22 August	1	*	1	4	*	4
24 August	1		2	0		0
26 August	1		1	4		2
30 August	0		0	0		1
8 September	-		0	-		0
10 September	-		1	-		1
16 September	-		0	-		0
20 September	-		0	-		0

* Died on 19 September.

sometimes when they were perched, but mostly flying; often the adults hit the young, with their talons interlocked, making them lose their balance and to lose height.

On 2 September the introduced young (age 124 d) was seen trying to kleptoparasitize a Booted Eagle (*Hieraetus pennatus*) which had caught a rabbit. On 8 September, one adult was seen eating in an oak tree 200 m from the fostered juvenile, which begged but was not fed. Two days later it was flushed from the ground while it was feeding on a rabbit, but we cannot be sure whether the rabbit had been killed by the eaglet or brought to it by the adults. These observations are in accordance with the decreasing feeding rate of the adults to their offspring which occurred during the postfledging period in other family groups studied (González et al. in prep.).

In conclusion, these observations proved that the introduction was successful, and the adopted young reached independence and dispersed normally. This kind of fostering during the postfledging period could be a valuable management technique useful in reintroducing salvage or confiscated young raptors or for the release of captive bred birds.

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Harrier Kills Mobbing Willet

MARILYN E. ENGLAND

On 2 July 1984, while studying the breeding biology of the Northern Harrier (*Circus cyaneus hudsonius*), on a Long Island, New York barrier beach, I saw a female harrier kill one of two mobbing Eastern Willets (*Catoptrophorus semipalmatus*). The incident took place on a tidal salt marsh where both species breed. Vegetation is predominantly *Spartina* grasses interspersed with marsh elder (*Iva frutescens*) in the slightly elevated, drier areas where willets nest. Dense stands of common reed (*Phragmites communis*) flank the marsh and provide nesting habitat for the harriers. I witnessed frequent encounters between harriers and willets, especially as the breeding season progressed. Female harriers hunted over the marsh areas adjacent to nests, which usually brought them near to, or over, willet nests. When this occurred, willet pairs mobbed the intruder. Prior to this observation, however, such incidents had failed to elicit more than a mild response (e.g., head-turning to look at the mobbers and/or leg-dropping) from a harrier.

Generally, harriers respond to mobbing by increasing their flight speed while moving away from the disputed area (Bildstein 1982; M. England pers. obs.). Sometimes a particularly persistent or bold assault is acknowledged with short bursts of chattering, a vocalization similar to "kekking", which I have heard used during nest defense. Avoidance maneuvers, such as those described by Bildstein (1982) for harriers being mobbed by passerines were also observed. These include "rolling", a change in flight elevation, and a shift from the "to and fro" pattern of "quartering" flight to straight-line flight, again while moving away from the area.

On 2 July, a female harrier, hunting low over the marsh, apparently passed close to a willet nest, as both members of the pair flew up and began mobbing the harrier. At first, the harrier continued moving in her original direction. Then, as one of the willets flew under the harrier from behind, the harrier slowed, then suddenly, at high speed, seized the willet in mid-flight in one foot. With the

prey dangling from the talons of her outstretched foot, the harrier glided approximately 50 m before landing. The harrier remained on the ground plucking her kill for 8 min while the surviving willet continued circling and calling overhead. When the harrier rose carrying the dead willet in two feet pressed close to her body, and flew approximately 0.5 km to the northeast, the remaining willet ceased calling.

An observation by Watson (1976) for the Hen Harrier (*Circus cyaneus cyaneus*) in Europe, concerns the taking of a mobbing Lapwing (*Vanellus vanellus*) in a similar fashion. In that instance, the Lapwing was released alive several minutes later. Harriers are dietary generalists capable of taking relatively large prey (Errington & Breckenridge 1936; Bent 1937; Craighead & Craighead 1956; Hamerstrom 1969). However, in the course of my three-year study, this is the first time predatory behavior was observed during mobbing.

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NEWS AND REVIEWS

Working Bibliography of the Golden Eagle and the Genus *Aquila* by Maurice N. LeFranc, Jr. and William S. Clark. National Wildlife Federation. Scientific Technical Series No. 7, 1983. xxx + 234 pp. Price \$14.95 U.S. + \$1.55 U.S. postage and handling. Available from Institute for Wildlife Research, National Wildlife Federation, 1412 16th St. N.W., Washington, D.C. 20036.

The Raptor Information Center of the National Wildlife Federation has earned a debt of gratitude from raptor biologists worldwide for its production of a series of working bibliographies on major taxa of birds of prey. This is the third of these keyworded, computer-generated reference works, having been preceded by volumes dealing with owls (Clark, R.J., D.G. Smith and L.H. Kelso, 1978. Working Bibliography of Owls of the World, NWF Scient./Tech. Ser. No. 1) and the Bald Eagle (Lincer, J.L., W.S. Clark and M.N. LeFranc, Jr. 1979. Working Bibliography of the Bald Eagle, NWF Scient./Tech. Ser. No. 2). The three books are the concrete results of a project devoted to the compilation of literature citations that was begun under Jeff Lincer's administration as first director of the Raptor Information Center and continued to successful completion under his successor, Bill Clark.

Because the present volume includes references to the genus *Aquila* worldwide, the organization of the specific format is more like that of the owl volume than the Bald Eagle bibliography. This format, by now familiar to raptor students here and abroad, consists of introductory material followed by a master list of citations, arranged alphabetically by author, with each entry assigned a reference number. This is succeeded by a permuted list of keywords, which provides cross-references to each author entry on the basis of up to a dozen or more selected keywords, which

collectively describe the major content of that particular entry; hence specific keywords deal with such subjects as nesting, distribution, research techniques, management and conservation.

The highlight of the introductory material in this volume is a foreword written by the late Leslie Brown (in his inimitable salty style) wherein he reviews some general features of the genus and describes the tedious "hack-work" (his word) required of raptor students who attempted to conduct literature searches before working bibliographies of this type were available. Chapter 1 contains the authors' introduction and acknowledgments, with information on the production and organization of the bibliography. Chapter 2 is an introduction to the members of the genus *Aquila*, with a paragraph or two devoted to the description, range and general characteristics of each of ten species (instead of 9 as recognized by Brown and some other authorities; the authors state their good reasons for treating the Steppe Eagle, *Aquila nipalensis*, as a full species instead of as a race of *A. rapax*). This completes the general and introductory material, and the working bibliography itself comprises the remainder of the chapters, which are arranged as follows: Chapter 3 - Master List of Citations (3459 entries), Chapter 4 - Permuted List of Keywords ("Abandonment" through "Wintering Population"), Chapter 5 - Species Index to Citations (ranging from 18 for Gurney's Eagle to 2305 for the Golden Eagle), Chapter 6 - Geographic Index of Citations (listed by sub-

region, nation, state, province, etc., for each continent), and Chapter 7 - List of Citations of Occurrences. There is also an appendix, with a useful glossary or dictionary of all keywords used in the bibliography.

Many good things could be said about the finished product, but its ultimate value will lie in the utility it provides in the context of an otherwise tedious literature search. I, for one, am grateful that the authors have not felt it necessary to restrict entries to only those appearing in referred scientific journals. Golden Eagle aficionados are aware that much useful information may be gleaned from the semi-popular or anecdotal accounts of the species that are included (e.g., Gordon, S.P. 1955. The Golden Eagle, king of birds, Citadel Press, New York, Olendorff, R.R. 1975. Golden Eagle Country, A.A. Knopf, Inc., N.Y.), and even from fictional works (e.g., Murphy, R. 1965. The Golden Eagle, E.P. Dutton & Co., N.Y.)

As is to be expected, the work is not without flaws. Any product that is largely the result of computer programming is bound to suffer from a few "glitches" and inconsistencies. My main concern is with the ambiguity which inevitably results from the use of keywords, which are the utilitarian "heart" of the method. The number of keywords assigned to a given entry ranges from a minimum of 3, generally for short notes with limited information, to 20 or more for more extensive monographs. What constitutes a valid or relevant keyword, and what criteria are used to determine the number of them selected to cross-reference a given bibliographic entry? Obviously, this is largely a matter of arbitrary choice by the compilers, and it is bound to produce some confusion and unsatisfactory allocations of information. To cite a few examples: there is only one entry under the keyword "Nest Construction" (!); the 13 entries under "Nest Adornment" do not include several references which should be listed, including the important monograph by D.H. Ellis (1979). Development of behavior in the Golden Eagle, Wildlife Monographs, No. 70. The Wildlife Society, Inc.); the book by Olendorff (1975) is cited under the keyword "Popular Monograph," but the equally anecdotal work by Gordon (1955) is not; Walter Spofford's report on the Golden Eagle aerial shootoff in west Texas (1964. The Golden Eagle in the Trans Pecos and Edwards Plateau of Texas, Audubon Cons. Rept. No. 1. National Audubon Society), is not listed under

"Conservation" despite its bearing the label of a conservation report; nor is it listed under the keyword "Aircraft."

There are numerous other examples, but these are enough to emphasize the cautionary message; use of a given keyword does not guarantee that all literature containing that specific information will be cited thereunder. People using the bibliography will soon discover this problem and adjust their search methods accordingly, and no doubt all readers will recognize the difficulty facing the editors in determining how many different keyword entries to extract from a given publication.

Among other items that would benefit from clarification, the heading of Chapter 7, "List of Citations of Occurrences," is somewhat misleading, and needs to include the further information given on page xx of the introduction so that readers will understand that this is a list of additional locality references for the Golden Eagle not included in the master list of citations (Chapter 3). I found another inconsistency in the fact that some foreign titles were given English translations in parentheses, while others were not. I wondered why some entries were listed as "title only," with no keyword cross-referencing. A case in point is the manuscript report by Glover and Heugly (1970). Golden Eagle Ecology in West Texas. Report to Natl. Audubon Soc., Colorado Coop Wildl. Res. Unit. Fort Collins), which contains important information on economic relations and management of eagles *vis a vis* livestock; perhaps the compilers didn't have access to a copy. Among other minor errors, I noticed that the two-part paper on Black Eagles in Tanzania by E.G. Rowe (1947). The breeding biology of *Aquila verreauxi* Lesson. Ibis 89:387-410 (Part I); 576-606 (Part II) was cited in reverse order, i.e., the second part is cited (and numbered) first.

These comments are not intended to detract from the basic value and genuine contribution of the book as a labor-saving repository of a great deal of useful information. Given the rapid rate of expansion of published material on the genus, it is to be hoped that the compilers of the parent organization will plan to update the listings from time to time (this should be another of the virtues of the computer-generated approach). The community of raptor enthusiasts are well served by these bibliographers; let's hope that the momentum will continue, and that similar works on other taxa will be forthcoming. — Joseph R. Murphy.

The 1986 Annual Meeting of The Raptor Research Foundation, Inc. — the Raptor Research Foundation will hold its annual meeting at the University of Florida, Gainesville, FL. 20-23 November 1986. MICHAEL W. COLLOPY, Dept. of Wildlife and Range Sciences, 118 Newins-Ziegler Hall, Univ. of Florida, Gainesville, FL 32611, will chair the Local Committee. KEITH L. BILDSTEIN, Dept. of Biology, Winthrop College, Rock Hill, SC 29733, will chair the Programs Committee.

European *Haliaeetus* East-West Symposium 1986. The European *Haliaeetus* Symposium is organized as a forum for the exchange of scientific findings in the field of raptor biology, as well as for an exchange of experience between experts from East and West on the subject of nature conservancy and conservation of species. The symposium is scheduled to take place 18 - 28 September 1986 in Heidelberg, Federal Republic of Germany. Plenary meetings will take place from 19 - 21 September, and excursions and tours are scheduled to take place 22 - 28 September, plus another series of meetings dealing with specialized topics. Please address inquiries regarding the symposium to: Deutsche Greifenwarte (German Raptor Center), Burg Guttenberg or Claus Fentzloff, D-6954 Burg Guttenberg/Neckar, Federal Republic of Germany.

RESOLUTIONS

The following resolutions were adopted by the Board of Directors and the General Membership of The Raptor Research Foundation, Inc., at The 1985 Raptor Research Foundation International Meeting and Symposium on the Management of Birds of Prey held 2 - 10 November 1985 in Sacramento, California.

Resolution #85-1. RE: The California Condor

WHEREAS, the wild population of California condors, currently only six birds, has been rapidly approaching extinction, in spite of all efforts to counteract the man-induced mortality factors that are the principal causes of the decline; and

WHEREAS, no effective means to reduce these mortality factors are yet in sight, and these mortality factors appear to be associated with existing foraging traditions of the population; and

WHEREAS, there appears to be no hope for recovery of the species in the absence of a fully viable captive population; and

WHEREAS, the fraction of the 21 currently-held captives that may become effective breeders is unknown; and

WHEREAS, the genetic viability of the existing captive population has been seriously questioned by all population geneticists that have been consulted by the recovery team; and

WHEREAS, the capture of the remaining wild birds might significantly increase the chances that a viable captive population can be achieved; and

WHEREAS, effective methods have been developed for reestablishment of wild vulture populations from captivity;

THEREFORE BE IT RESOLVED that (1) the remaining wild California condors be taken captive as soon as possible; and (2) until a healthy self-sustaining captive population has been achieved, no release of captives to the wild should be attempted, and (3) that releases of California condors to the wild be made as soon as advisable, and that they be directed to historic regions that offer effective protection from detrimental human influences.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-2. RE: Old Growth Management on Federal, State, and Private Lands

WHEREAS, many of the raptor species inhabiting the forests and woodlands of the United States, including such sensitive species as the Goshawk, Great Grey Owl and Spotted Owl, are wholly or partially dependent on mature and old growth trees and/or snags for nesting, roosting, cover and/or foraging; and

WHEREAS, present silvicultural systems do not adequately address the maintenance and recruitment of old growth tree groves in densities to sustain adequate raptor populations;

THEREFORE BE IT RESOLVED that The Raptor Research Foundation, Inc., does hereby take the position that comprehensive old growth policies, in the spirit of multiple use-sustained yield principles, be implemented which allow for natural fluctuation and movement of raptor populations by local, state and federal agencies responsible for management of wildlife populations and their habitats.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-3. RE: Appreciation to RRF Founders

WHEREAS, the need for an organization focusing on communication, raptor management and conservation was apparent in the mid-1960s because of widespread population declines and habitat loss; and

WHEREAS, in an effort to accomplish the above goals, Donald V. Hunter, Jr., Byron E. Harrell and Paul F. Springer became the founding members, and George M. Jonkel, the first secretary of the Raptor Research Foundation; and

WHEREAS, the Raptor Research Foundation (RRF) has since grown in stature, membership, and influence as a result of those original efforts; and

WHEREAS, the efforts of RRF and its membership is believed to have significantly contributed to the increased awareness, conservation, and proper management of birds of prey;

NOW, THEREFORE BE IT RESOLVED that The Raptor Research Foundation, Inc., formally, and with great pleasure, recognizes the insight, commitment and leadership of our founding members, Donald V. Hunter, Jr., Byron E. Harrell and Paul F. Springer and its first secretary, George M. Jonkel;

FURTHER, that a copy of this resolution, appropriately prepared, be presented to these key individuals.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-4. RE: Societal Priorities

WHEREAS, birds of prey, being at the top of the food chain, are extremely sensitive to environmental degradation such as habitat loss and chemical pollutants; and

WHEREAS, these negative impacts are all directly or indirectly the result of human population pressures; and

WHEREAS, conservation issues cannot be fully addressed until socioeconomic justice and political stability are achieved;

THEREFORE BE IT RESOLVED that The Raptor Research Foundation, Inc., recognizes that human population and increasing per capita resource use in the developed world are one of the greatest threats to the survival of raptor populations and that The Raptor Research Foundation, Inc., encourages appropriate agencies to effect the transition from a growth and consumer-oriented society to a stable conserver society.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-5. RE: Government Game and Nongame Programs

WHEREAS, non-game wildlife provides important recreational, aesthetic, ecological, existence, economic, and genetic benefit to the people of the United States; and

WHEREAS, the U.S. Fish and Wildlife Service and other federal agencies are charged with the responsibility of managing and protecting migratory birds; and

WHEREAS, recent surveys and studies clearly demonstrate that the public supports management of non-game wildlife and prevention of extinction; and

WHEREAS, fish and wildlife service programs for non-endangered wildlife species currently are predominantly game-oriented; and

WHEREAS, early detection of species declines is an important part of species protection and prevention of extinction;

WHEREAS, current bird monitoring programs do not adequately represent trends for many bird species, including raptorial birds;

NOW, THEREFORE BE IT RESOLVED that The Raptor Research Foundation, Inc., urges the U.S. Fish and Wildlife Service to redirect its research and management efforts to create a reasonable balance between game and non-game programs; and

BE IT FURTHER RESOLVED that The Raptor Research Foundation, Inc., urges the U.S. Fish and Wildlife Service and other appropriate agencies to adopt, as a principal objective of their non-game programs, the prevention of non-game wildlife from becoming threatened or endangered and that the non-game program include, but not be limited to, monitoring non-game bird populations that are not now being effectively monitored.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-6. RE: Welfare of Raptors in Mexico

WHEREAS, Mexico is comprised of high ecological diversity and varied natural habitats; and

WHEREAS, there exists very little knowledge on natural resources in terms of inventories, management, conservation, and possible impact of industries, for example, petroleum; and

WHEREAS, the high species diversity of raptors is under constant threat by habitat modification, pollution, hunting pressure, and trade;

THEREFORE BE IT RESOLVED that The Raptor Research Foundation, Inc., respectfully suggests that the government of Mexico pay special attention to the following points:

- (1) urgently ratify and implement the convention on trade in endangered species;
- (2) habitat conservation and management;
- (3) stopping the illegal trade of wildlife, with particular emphasis on Peregrine Falcons and other raptors, at the national and international levels;
- (4) develop educational programs for wildlife conservation integrating the concept of planned development;
- (5) monitor the use, abuse and impact of pesticides on wildlife with particular emphasis on raptors;
- (6) support the training and education of specialists in wildlife management either in the country or abroad; and
- (7) support long-term research projects oriented toward the integration of conservation strategies into the developmental process of the country.

BE IT FURTHER RESOLVED that The Raptor Research Foundation, Inc., willingly offers its assistance to the Mexican government and expertise that would facilitate the accomplishment of these objectives.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer,
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-7. RE: Illegal Trade of Peregrine Falcons in Mexico

WHEREAS, *Falco peregrinus* is a bird species in danger of extinction, included in Appendix I of the cites convention, and protected by the convention on migratory birds signed by Canada, USA, and Mexico; and

WHEREAS, information from international organizations indicates that an illegal international trade exists between Mexico and other countries of the world involving live and dead individuals of the species; and

WHEREAS, some of those individuals have been identified as migratory birds from the northern breeding grounds in transit through Mexico to their wintering areas to the south;

THEREFORE BE IT RESOLVED that The Raptor Research Foundation, Inc., supports the ongoing trade investigations aimed at ending violations of relevant Mexican and international laws protecting *Falco peregrinus*.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-8. RE: International Year for Birds of Prey

WHEREAS, birds of prey are found in virtually every country of the world, often migrating freely across international borders; and

WHEREAS, birds of prey, being at the top of the food chain, constitute important barometers of environmental change; and

WHEREAS, there is an international recognition and appreciation for birds of prey; and

WHEREAS, there is international concern for the welfare of those birds of prey due to declines in some populations because of habitat loss, widespread pollution, illegal trade, persecution and other human-related problems; and

WHEREAS, the ICBP World Working Group on Birds of Prey is hosting the next world conference on birds of prey in Eilat, Israel in 1987; and

WHEREAS, The Raptor Research Foundation, Inc., consists of over 700 specialists on the biology, conservation, and public awareness of birds of prey, from all over the world;

THEREFORE BE IT RESOLVED that The Raptor Research Foundation, Inc., urges the United Nation's UNEP-IUCN to proclaim 1988 as "The International Year for Birds of Prey."

FURTHER, that copies of this resolution be sent to the executive director of the Office of Environmental Programs, UNEP, and all other appropriate international bodies.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-9. RE: Falconer's Contribution

WHEREAS, important raptor conservation techniques, including captive breeding and reintroduction of raptors, have been pioneered and developed largely by falconers;

THEREFORE BE IT RESOLVED that the conservation community owes falconers a debt which seldom has been recognized, and encourages the continued participation of falconers in raptor conservation projects.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-10. RE: Grassland Raptors

WHEREAS, many birds of prey are vitally dependent upon grasslands for their food base, i.e., small rodents; and

WHEREAS, the absence of this food base will reduce breeding effort or cause these species to not breed at all; and

WHEREAS, some of these species of raptors are considered as endangered or threatened in many states; and

WHEREAS, grasslands also are important to many species of ground nesting birds; and

WHEREAS, the conversion of grasslands to cropland has resulted in serious soil erosion problems; and

WHEREAS, the "sodbuster" and conservation reserve provisions will protect and restore grassland habitat;

THEREFORE, BE IT RESOLVED that The Raptor Research Foundation, Inc., strongly urges Congress to include the "sodbuster" and conservation reserve provisions in the 1985 farm bill.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-11. RE: Gray's Harbor Bay

WHEREAS, the 500 acre section of Gray's Harbor Bay known as *Bowerman Basin* has been documented to be the largest concentration of migrant shorebirds on the Pacific coast south of the Copper River Delta, Alaska; and

WHEREAS, Bowerman Basin is an intensively used feeding and resting area for 3 subspecies of wintering and migrant Peregrine Falcons; and

WHEREAS, the port of Gray's Harbor proposes to fill this estuarine wetland/mudflat for speculative industrial development; and

WHEREAS, federal and state environmental protection acts/regulations and the respective federal and state resource agencies have been unable to secure permanent protection of Bowerman Basin;

THEREFORE, LET IT BE RESOLVED that The Raptor Research Foundation endorses and supports proposals to establish the *Bowerman Basin National Wildlife Refuge*.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Resolution #85-12. RE: Appreciation to Local Committee

WHEREAS, the 1985 annual RRF meeting in Sacramento, California, was an unprecedented success, involving approximately 900 individuals, representing 40 countries; and

WHEREAS, the success of this meeting was due primarily to the efforts of the local committee co-chairmen, Butch Olendorff, Nancy Venizelos, Dave Harlow, and their committee members; and

THEREFORE, BE IT RESOLVED that the RRF gratefully expresses their appreciation for a job well, done to those individuals; and

FURTHER, the RRF similarly expresses their appreciation to the BLM, San Francisco Zoological Society, USFWS, and other agencies and organizations for allowing their employees the time to make this annual professional meeting the success that it was.

THE RAPTOR RESEARCH FOUNDATION, INC.

Jeffrey L. Lincer
President, The Raptor Research Foundation, Inc.

WITNESS my hand and official seal, this 19th day of December, A.D. 1985

Joan Ann Carter
Notary Public, State of Florida

Hawk Mountain Sanctuary Association 10th Annual Award for Raptor Research - The Hawk Mountain Sanctuary Association is accepting applications for its 10th annual award for raptor research. To apply for the \$750 award, students should submit a brief description of their research program (5 pages maximum), a curriculum vitae, and 2 letters of recommendation **by 15 October 1986 to Stanley E. Sennner, Executive Director, Hawk Mountain Sanctuary Association, Route 2, Kempton, Pennsylvania 19529**. The Association's Board of Directors will make a final decision early in 1987. Only students enrolled in a degree-granting institution are eligible. The award will be granted on the basis of a project's potential to improve understanding of raptor biology and its ultimate relevance to the conservation of North American raptor populations.

Leslie Brown Memorial Grant (Deadline Extended) — The Raptor Research Foundation, Inc., announces the availability of a \$500 grant to provide financial assistance to promote the research, or the dissemination of information, on birds of prey. Applicants must send a resume (vitae), specific study objectives, an account of how funds will be spent, and a statement indicating how the proposed work would relate to other work by the applicant and to other sources of funds. Proposals concerning African raptors will receive highest priority between proposals of otherwise equal merit.

Application material must be received by **7 November 1986**. Proposals, donations and inquiries about tax-exempt contributions to the fund should be sent to: **Dr. Jeff Lincer, Chairman, RRF Leslie Brown Memorial Fund, 4718 Dunn Drive, Sarasota, FL 33583, U.S.A.**

THESIS ABSTRACTS

THE BIOGEOCHEMISTRY OF PEREGRINE FALCON FEATHERS

Secondary remiges were collected from 92 Peregrine Falcon (*Falco peregrines*) nestlings in the summer of 1979 and 1980 at 1 West Greenland and 4 North American breeding localities. This study's purpose has been to determine if natal origin of peregrines could be identified using feather trace element quantities obtained by instrumental neutron activation analysis (INAA). Gamma-ray spectra analysis of irradiated feather samples identified 14 trace element quantities present in the distal most feather portion. Multivariate discriminant function analysis of spectral data provided a means of separating Peregrine Falcons from 5 breeding localities into groups of similar natal origin.

Twenty-two additional feather samples were collected from migrant peregrines at South Padre Island, Texas and Mobile Point, Alabama during autumnal migration periods. Trace element analysis of migrant peregrine feather samples and comparison with nestling peregrine feather sample analyses provided a method potentially useful in predicting natal origin of North American migrant peregrines with substantial accuracy. Variation in prediction capability results when groupings of selected traced element quantities are utilized in formulating predictive multivariate discriminant functions.

Trace element analysis of feathers using INAA provided an effective means of identifying levels of environmentally harmful elements such as Mercury which could adversely affect population densities in remote regions of the peregrine's range. As peregrine wintering locality studies by others expand in Latin America, similar "ground truth" data from feathers grown by peregrines in these regions will enhance isolating discrete wintering localities of remote northern breeding populations, information vital to overall management of this endangered species. **Parrish, J.R., M.S. Thesis, Univ. of Alabama, Tuscaloosa. Thesis directed by D.T. Rogers, Jr., 1983.**

SOME ASPECTS OF THE REPRODUCTIVE BIOLOGY OF TUNDRA PEREGRINE FALCONS

A dense, productive population of tundra peregrine falcons (*Falco peregrinus tundrius*) was studied over five years on a 450 km² study area located along the northwest coast of Hudson Bay. The number of territorial pairs varied over the years from 17 to 26. A mean internest distance of 3.3 km represents a nesting density for the population that is among the highest on record for the species. Morphometric and plumage characteristics of adults in the study population

suggest clinal variation between populations of *F.p.tundrius* from north and *F.p. anatum* to the south. Pairs of falcons nested on cliffs of less than 30 m in height. Most nest cliffs had a southern exposure, but pairs nesting at north-facing sites did not suffer lower reproductive success. Falcons arrived on the breeding grounds before most migratory prey species (mid-May) and left the area before October. Mean date of clutch initiation over three years was June 7, but this date was significantly delayed in one year of poor spring weather (relatively lower temperatures and high precipitation).

Nineteen species of birds and three species of mammals were used as prey by the study population; however, in most years the bulk of the diet consisted of six species of birds and one mammal. A dramatic increase in the number of territorial pairs of falcons, coupled with changes in various measures of reproductive performance, in a year of high microtine rodent abundance suggests that the use of mammals by falcons can be significant in some years.

In most years, successful pairs produced about 35 young, or about two young per occupied territory per year. The sex ratio of nestlings was not significantly different from equality. Despite changes in reproductive performance noted in a year of high prey abundance, there were no significant differences among years in clutch size, brood size, or number of young fledged per territorial pair.

Mean clutch size (3.62 ± 0.59) was comparable to that for peregrine populations from both arctic and more temperate latitudes. Mean brood size (2.79 ± 0.78) was most similar to that reported for populations in the central Canadian arctic and Greenland, but was also similar to, and even greater than, that from other populations at more temperate latitudes. Earlier suggestions by some authors that peregrines lay fewer eggs in the arctic part of their range was not supported by data from the study population.

Twenty-nine separate nesting territories were used in the five years of the study. Territories were held by adult peregrines in all cases. The oldest female on territory was at least five years old, the youngest was three. The oldest male was at least five years old, the youngest was two. Annual turnover of adults was estimated to be 25% (males 16%, females 30%). Maximum annual mortality was estimated to be 23% (males 16%, females 27%). Peregrines showed a high degree of fidelity to previously used nest sites; movement between territories was recorded only once.

Peregrines competed intensively for nesting territories early in the spring, but competition dropped off as breeding commenced. For the most part, territorial interactions were sex specific. Males were more territorial than females in terms of interaction rate and in the distance to which they would pursue intruders. Observation of territorial interaction, and evidence of the existence of non-breeding, non-territorial adults, suggested that the breeding density of the falcon population was limited by a shortage of nesting habitat created through territoriality. Apparent change in territory size in a year of high prey abundance supports the hypothesis that expressions of territoriality and territory size in birds are often mediated by food supply.

Total and partial nesting failures were recorded in the study population. Ten percent of all territorial pairs failed to lay. Failure of territorial pairs to lay accounted for 41% of all failures. Losses of entire clutches accounted for 48% failures, while losses of complete broods made up only 11% of failures. Seventy-four percent of all territorial pairs were successful in fledging young. Peregrines managed a full hatch with 44% of all clutches. At successful nests, hatching success (% of all eggs to hatch) was 87% and nestling mortality (% of all young hatched that do not fledge) was 14%.

Female peregrines on nesting territories for the first time appeared to lay later, had significantly smaller clutches, but did not show a difference in the number of young fledged when compared to females with greater experience on nesting territories. Falcon pairs nesting in close proximity or in areas of higher intraspecific nesting density did not show lower clutch size, hatch success, or number of young fledged, suggesting that the effect of intraspecific strife on reproductive success was negligible.

Asynchronous hatching was commonly observed in the study population. An investigation of the effects of hatch asynchrony on reproductive success, conducted over two years, showed that 7% of all chicks produced died as a result of brood reduction associated with asynchronous hatching. Most chicks that died were the last-hatched in asynchronous broods of four; about half of the last-hatched members of these broods died within their first five days of life. Mortality occurred through starvation. Surviving last-hatched members of asynchronous broods of four did not show significantly different growth rates compared to other chicks from different hatch positions. Mortality did not appear related to the food available to the parents, but to the inability of last-hatched young to compete with older siblings during feedings. Differential survival of last-hatched chicks in asynchronous broods was linked to differences in the attentiveness of adult females (feeding rate and time spent brooding), prey size, and possibly, nest ledge size. Asynchrony of hatching and brood reduction observed in the study population did not suggest an adaptation in keeping with the brood reduction hypothesis.

Court, Gordon S. 1986. Thesis. Department of Zoology, University of Alberta, Alberta T8A, 1V7, CANADA. Present address: 913 Alder Avenue, Sherwood Park, Alberta, CANADA T8A 1V7.

R A P T O R R E S E A R C H

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

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Raptor Research (ISSN 0099-9059) welcomes original manuscripts dealing with all aspects of general ecology, natural history, management and conservation of diurnal and nocturnal predatory birds. Send all manuscripts for consideration and books for review to the Editor. Contributions are welcomed from throughout the world, but must be written in English.

INSTRUCTIONS FOR CONTRIBUTORS: Submit a typewritten original and two copies of text, tables, figures and other pertinent material to the Editor. Two original copies of photographic illustrations are required. *Raptor Research* is published in a double-column format and authors should design tables and figures accordingly. **All submissions must be typewritten double-spaced** on one side of 8½ x 11-inch (21½ x 28 cm) good quality, bond paper. Number pages through the Literature Cited section. The cover page should contain the full title and a shortened version of the title (not to exceed 30 characters in length) to be used as a running head. Author addresses are listed at the end of the Literature Cited section. Authors should indicate if present addresses are different from addresses at the time the research was conducted. When more than one author is listed, please indicate who should be contacted for necessary corrections and proof review. Provide an abstract for each manuscript more than 4 double-spaced typewritten pages in length. Abstracts are submitted as a separate section from the main body of the manuscript and should not exceed 5% of the length of the manuscript. Acknowledgments, when appropriate, should immediately follow the text and precede the Literature Cited. Both scientific and common names of all organisms are always given where first appearing in the text and should conform to the current checklists, or equivalent references, such as the A.O.U. Checklist of North American Birds (6th ed., 1983). Authors should ensure that all text citations are listed and checked for accuracy. If five or fewer citations appear in the text, place the complete citation in the text, following these examples: (Brown and Amadon, Eagles, Hawks and Falcons of the World. McGraw-Hill, New York. 1968), or Nelson (*Raptor Res.* 16(4):99, 1982). If more than five citations are referenced, each should include author and year (e.g., Galushin 1981), or in a citation with three or more authors, the first author and year (e.g., (Bruce et al. 1982)). Citations of two or more works on the same topic should appear in the text in chronological order (e.g., (Jones 1977, Johnson 1979 and Wilson 1980)). Unpublished material cited in the text as "pers. comm.," etc., should give the full name of the authority, but must not be listed in the Literature Cited section. If in doubt as to the correct form for a particular citation, it should be spelled out for the Editor to abbreviate.

Metric units should be used in all measurements. Abbreviations should conform with the Council of Biology Editors (CBE) Style Manual, 4th ed. Use the 24-hour clock (e.g., 0830 and 2030) and "continental" dating (e.g., 1 January 1984).

Tables should not duplicate material in either the text or illustrations. Tables are typewritten, **double-spaced throughout**, including title and column headings, should be separate from the text and be assigned consecutive Arabic numerals. Each table must contain a short, complete heading. Footnotes to tables should be concise and typed in lower-case letters. Illustrations (including coordinate labels) should be on 8½ x 11-inch (21½ x 28 cm) paper and must be submitted flat. Copies accompanying the original should be good quality reproductions. The name of the author(s) and figure number should be penciled on the back of each illustration. All illustrations are numbered consecutively using Arabic numerals. Include **all** illustration legends together, typewritten **double-spaced**, on a single page whenever possible. Line illustrations (i.e., maps, graphs, drawings) should be accomplished using undiluted india ink and designed for reduction by 1/3 to 1/2. Drawings should be accomplished using heavy weight, smooth finish, drafting paper whenever possible. Use mechanical lettering devices, pressure transfer letters, or calligraphy. Typewritten or computer (dot matrix) lettering is **not** acceptable for illustrations. Use of photographic illustrations is possible but requires that prior arrangements be made with the Editor and the Treasurer.

A more detailed set of instructions for contributors appeared in *Raptor Research*, Vol. 18, No. 1, Spring 1984, and is available from the Editor.

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